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TEXAS INDUSTRIAL ENERGY EFFICIENCY PROGRAM

Highlights from the Texas Industrial Energy Efficiency Program

Newsletter Volume 7, Number 4, December 2025

Greetings from the Texas Industrial Energy Efficiency Program!

Upcoming Events

Industrial Energy Efficiency Podcast

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

Happy Holidays!

Energy Transition Webinar Series

TBD

Energy Transition Institute
UH ENERGY

12-1 PM
Biweekly on Tuesdays

Contact us
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uh-energy/energy-centers/eti

ENERGY TRANSITION WEBINAR SERIES

Energy in Action Seminar Series

January 26, 2026 | 4:00 - 6:00 PM

Location TBD

Energy Transition Institute
UH ENERGY

ENERGY IN ACTION
SEMINAR SERIES

Join leaders in technology, policy, and innovation across all sectors of industry, academia, and government.

- DIALOGUES ON LATEST TRENDS IN ENERGY
- ON-CAMPUS AT THE UNIVERSITY OF HOUSTON
- 1 HOUR SEMINAR + 1 HOUR NETWORKING RECEPTION

Last Month's Events

Reuters Events: Energy LIVE

December 9-10, 2025

The Energy LIVE Exhibition is your one-stop shop where the future of energy takes shape – live and in motion. The exhibition had 100+ innovative booths, 3,000+ attendees, and gave the participants a chance to uncover the groundbreaking solutions and technologies set to transform the energy sector.

Energy in Action Seminar Series

Beyond the Hype: Amplifying AI Impacts in Fuel and Petrochemical Industry

December 9, 2025

Leo Chiang, Senior Director, Corporate Technology, The Lubrizol Corporation
In the digital era, artificial intelligence (AI) is transforming how industries operate—powering breakthroughs in image analytics, large language models (LLMs), deep learning, reinforcement learning, hybrid modeling, and real-time decision-making. This talk reframed the narrative around AI, not as a hype or threat to replace human decisions, but as an opportunity to amplify impact in fuels and petrochemicals industry. The talk emphasized the need for Responsible/Trustworthy AI and presented industrial examples on how humans and AI must be working in the loop. An important aspect was to understand how to incorporate AI methods to assist humans to accelerate discovery in research and to make well-informed decisions in manufacturing operations. The other aspect was to allow humans to incorporate engineering and science domain knowledge to make AI methods smarter. This talk aimed to showcase AI success stories in Chemical Engineering. The discussion extended to anticipated research paths, the necessity for workforce development, and the imperative collaboration between academia, technology providers, and the industry to shape the AI future together.

Energy Transition Webinar Series

Unlocking Nature's Power for a Healthier, Safer, More Resilient Houston

December 2, 2025

Jaime Gonzalez, Founding Executive Director, University of Houston Institute for Ecological Resilience
Houston is one of the nation's most biologically and sociologically diverse regions—vibrant, dynamic, entrepreneurial, and culturally rich. Yet our communities face intersecting challenges, including extreme weather, biodiversity loss, and persistent public-health burdens. Nature and nature-based solutions offer powerful pathways to create cooler, spongier, healthier, more resilient, and more biodiverse neighborhoods across Greater Houston. This talk explored the risks facing our region, and the opportunities and barriers scaling nature-based solutions. The talk concluded by providing a vision for how and where the new UH Institute for Ecological Resilience seeks to be a change agent in this critical space.

View the recording here: Unlocking Nature's Power for a Healthier, Safer, More Resilient Houston

Coogs for Energy Hackathon
November 21-22, 2025

The Energy Transition Institute (ETI) hosted the second edition of the Coogs for Energy Hackathon on November 21–22, sponsored by ExxonMobil, Honda, and the Glenn Bailey Foundation. It featured 12 multidisciplinary teams representing various UH schools and colleges.

Participants presented solutions to problem statements submitted by leading industry partners, including ExxonMobil, Shell, and the Sustainability Committee of the FIFA World Cup 2026 Houston Host Committee.

Over a 10-day research period leading up to the event finale, the teams, guided by industry mentors and UH faculty, worked on developing innovative solutions to their assigned problem statements.

On November 21, the teams pitched three early-stage solutions to mentors and received feedback. On November 22, they built digital or physical prototypes and presented their final proposals to a panel of judges.

The winning teams, awarded $6,000, $3,000, and $1,500 respectively, were as follows:

- Team Net Positive were the winners for their work on “Sustainable Soccer Fields for Communities.” In the team were Amir Abutalib, Edgar Turizo-Pinilla, Victoria Guaimare Pereira, Julio Rios Brache, Isabella Galvez Fierro, and Nicolas Bravo Caldas.
- Team Energy Drinkers were the runners-up and they worked on “Green Corridor Transit Hub Innovation.” The team members were Cindy Yang, Harper Jones, Elijah Clark, Emily Perez, Noah Hawver, and Jonathan Cummins.
- Team Watt Warriors were in third place with their project on “Advanced Recycling: Detection and Sorting of Impurities in Plastic Feedstock.” Their team had Paul Sabong, Shriyans Sai Ganipisetti, Cameron Cooley, Oscar Portillo, John Rubio, and Luke Knape.

There were also three mentors' choice awards, each with a cash prize of $1,200.

- Team Watt’s received the Mentors' Choice Award for Complete Prototype (“Mapping Urban Heat Island Impacts at the University of Houston”)
- Team Energy Coalition got the Mentors' Choice Award for Due Diligence (“Securing Future Supply of Critical Minerals Including Lithium”)
- Team Watt-the-Hack received the Mentors' Choice Award for Technical Solution (“Participation of the Datacenter to the Grid Stabilization”).

More information at Second Coogs for Energy Hackathon a Resounding Success | University of Houston

Energy In Action Seminar Series

November 17, 2025

Google Cloud Talk: AI, Energy, and Data Centers

Raiford Smith, Global Market Lead for Power & Energy, Google Cloud
The growth of AI and energy are inexorably linked. How will these two industries work together to solve 21st-century challenges? This talk explored how growth in AI is leading to record investments in energy infrastructure. Additionally, it discussed how that growth is expected to transform the energy sector – from the technologies and benefits of widespread AI adoption to growth in both traditional and carbon-free energy resources.

Routes for Methanol Production and their Efficiencies

By Carla Romero & Hisham Habli

Introduction

Used as a feedstock, a solvent, and for research, methanol is one of the largest chemical productions in the world, totaling over 90 million tons a year. It also accounts fora large chunk of demand or hydrogen, below ammonia production and oil refining production. Methanol is used in various ways, and is produced by several methods, as shown in figure 1. (The biomass route, as shown In Figure 1, is not discussed in this article.) Just like many chemical processes, methanol production consumes a lot of energy; so it is useful to determine on a thermodynamic basis which method can prove to be more energy efficient before any design configurations are considered.

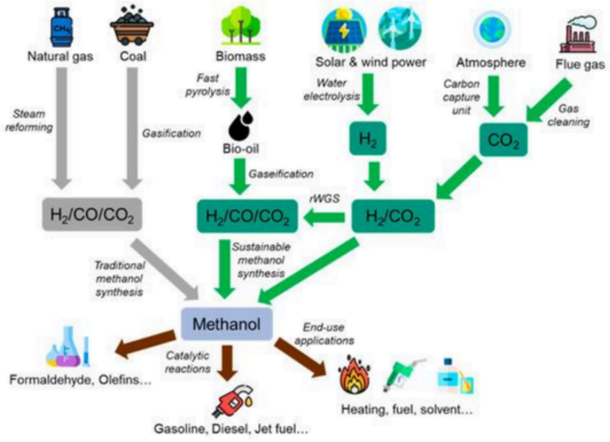

Figure 1 Methanol Production Routes Visual [1].

One method to assess efficiency of this process is through the first-law efficiency (also called Thermal Efficiency). This compares the heating value (LHV) of the produced methanol with the value of the inputs at their heating value. The energy required to produce the feedstock or dispose of the byproducts are not included.

In this case, the LHV represents the combustion energy, which is the heat released when a fuel burns with the product water remaining as vapor. Using LHV rather than higher heating value (HHV) reflects real-world industrial conditions where exhaust gases leave equipment hot [2]. The energy input should include energy for compression, methanol purification, and process heating. The energy for compression in the process is less than 10kJ/mol of methanol produced [3], which is negligible compared to the feedstock heating value. The energy for product purification should be provided by heat integration with the exothermic methanol synthesis reaction. Most of the energy required for feed heating should be provided by product cooling and has little impact on the comparison of the following four processes that will be discussed.

$$E = \frac{Useful\ energy\ output}{Total\ energy\ input}$$

$$= \frac{LHV\ of\ methanol\ produced}{\Sigma\ \text{Energy inputs}}$$

Steam Methane Reforming (SMR): The Natural Gas Route

The natural gas-based route is the dominant/most mature method for methanol production. It accounts for approximately 90% of global methanol synthesis [4]. This process is made up of three fundamental stages: synthesis gas (syngas) production via steam methane reforming, syngas conversion to crude methanol, and methanol purification through distillation. The primary steam methane reforming reaction is highly endothermic; it requires significant external heat input (typically methane combustion in furnace).

$$CH_4 + H_2O \rightarrow CO + 3H_2 \quad \Delta H = +206.1\ kJ/mol\ (1)$$

The typical operating temperatures for this process range from 800–900°C at pressures of 20–30 bar [5]. The heat of reaction is most commonly supplied by natural gas from the same source as the feedstock or by the burning of the excess hydrogen produced. The conversion of syngas to methanol occurs via an exothermic reaction [6]:

$$CO + 2H_2 \rightarrow CH_3OH \quad \Delta H_{298} = -90.64\ kJ/mol\ (2)$$

The CO hydrogenation reaction is favored at low temperatures and high pressures according to Le Chatelier's principle. Industrial synthesis typically operates at 50–100 bar and 200–300°Cwith $Cu/ZnO/Al_2O_3$ catalysts [5]. The energy required for methanol purification is again typically supplied by the heat of reaction [7].

Energy Efficiency

The energy efficiency of this process can be evaluated in two ways: one where excess hydrogen is combusted internally as fuel (A),and another where it is recovered as a coproduct (B).

Method A

When assessing efficiency in the process where excess hydrogen is combusted internally as fuel, it is found that the combined SMR (R1)and methanol synthesis (R2) requires 1 mol of methane feedstock to produce 1 mol of methanol, with no external fuel input.

$$E_{SMR} = \frac{LHV_{MeOH}}{LHV_{NatGas}} = \frac{638\ KJ/mol}{802\ KJ/mol} = 79\% \qquad Eq2$$

It is important to note that this SMR route produces more hydrogen than what the methanol synthesis requires. This is because the syngas H_2/CO ratio is 3:1, while methanol synthesis only requires 2:1. So, excess hydrogen can be combusted to drive the reforming reaction, converting nearly all carbon in the feedstock to methanol rather than CO_2. This heat integration makes the process essentially "self-fueling" once steady-state operation is achieved, attaining a first-law efficiency of 79%.Additionally, this process produces minimal amounts of CO2 when excess hydrogen production is used for fuel.

Method B

When assessing efficiency in the process where excess hydrogen is a co-product, the combined SMR and methanol synthesis requires 1 mol of feedstock and at least 0.26 mol of fuel to fire the reformer for every mol of methanol produced. When accounting for both feed stock and external fuel as inputs, and both methanol and hydrogen as outputs, the energy balance reflects a higher efficiency of 87% where the excess hydrogen is accounted as another product rather than combusted internally. This process configuration produces at least0.35 kg of CO_2 per kg methanol from combustion of the external fuel.

$$E_{SMR} = \frac{LHV_{MeOH}}{LHV_{NatGas}} = \frac{638\frac{KJ}{mol} + 242\frac{KJ}{mol}}{1.26\ \times 802\ KJ/mol} = 87\% \quad Eq.3$$

<u>Coal Gasification: The Coal Route</u>

Coal gasification produces syngas through the partial oxidation of coal with oxygen and steam at high temperatures. This route dominates in regions with abundant coal resources, like China, where over 77% of the methanol is produced in this way [8]. Coal gasification involves several simultaneous reactions with different thermodynamic characteristics. The primary gasification reactions are:

$$C + H_2O \rightarrow CO + H_2 \quad \Delta H = +131\ kJ/mol\ (3)$$

$$C + O_2 \rightarrow CO_2 \quad \Delta H = -394\ kJ/mol\ (4)$$

$$C + ½O_2 \rightarrow CO \quad \Delta H = -111\ kJ/mol\ (5)$$

$$C + CO_2 \rightarrow 2CO \quad \Delta H = +172\ kJ/mol\ (6)$$

Note that the complete combustion reaction(Reaction 4) is critical for providing the thermal energy needed to drive the endothermic gasification reactions. In practice, gasifier operators balance oxygen supply to maximize carbon conversion to syngas while generating sufficient heat. More complete combustion provides more heat but wastes carbon as CO_2 ;less complete combustion (partial oxidation)improves carbon utilization but requires external heat input [5].

Energy Efficiency

For every mole of methanol produced, approximately 2.4 mol of carbon (as coal) is required.

$$E_{Coal} = \frac{LHV_{MeOH}}{(2.4 \times LHV_{Coal})} = \frac{638\ KJ/mol}{2.4 \times 394\ KJ/mol} = 67\%\ Eq.4$$

This analysis does not include the cost associated with the amount of energy required for the air separating unit, auxiliary power, compression, Rectisol cleanup, pumps, distillation, carbon emissions or other pollutant costs associated with coal gasification. The 67% efficiency shows the big fundamental disadvantage of the coal gasification process, which is because coal is mainly carbon with very little hydrogen, unlike natural gas (CH_4),which already contains four hydrogen atoms per carbon. So, coal must generate nearly all its hydrogen through the water-gas shift reaction, which at the same time produces CO_2 as a byproduct. This means a significant fraction of the coal's carbon atoms end up as waste CO_2 rather than product methanol, explaining why2.4 moles of carbon are needed per mole of methanol versus roughly 1:1 for natural gas.

Direct CO_2 Hydrogenation: Green Methanol Route

The direct CO_2 hydrogenation reaction is mildly exothermic. This reaction is less exothermic than CO hydrogenation (−90.64 kJ/mol) and shows higher thermodynamic stability of CO_2 compared to CO. Also, compared to the CO route, this reaction produces water as a byproduct, consuming one additional mole of hydrogen.

$$CO_2 + 3H_2 \rightarrow CH_3OH + H_2O \quad \Delta H_{298} = -49.5\ kJ/mol\ (R7)$$

Energy Efficiency

The only input in this reaction that has any heating value is hydrogen. The energy required to produce carbon dioxide by any method is beyond the scope of this article. For the output, water has no heating value, so only methanol is considered, assuming no side reactions. While no carbon dioxide is produced, wastewater is produced.

$$E_{CO2\ Hydr.} = \frac{LHV_{MeOH}}{3 * LHV_{H_2}} = \frac{638\frac{KJ}{mol}}{3 * 242\frac{KJ}{mol}} = 88\% \qquad Eq.5$$

The CO2 Reduction Route

The CO2 reduction to CO reaction (8) is endothermic:

$$CO_2 \rightarrow CO + \frac{1}{2}O_2 \quad \Delta H_{298} = +283\ kJ/mol\ (R8)$$

Unlike the direct CO2 hydrogenation route, this route electrochemically reduces the carbon dioxide to carbon monoxide (reaction 8). This carbon monoxide is then reacted with hydrogen, shown in reaction 2.

Energy Efficiency

The heat of reaction does not account for electrochemical losses from dissipation and other process loss considerations. Nevertheless, it is a good starting point for estimating its energy efficiency.

$$E_{CO2\ Red.} = \frac{LHV_{MeOH}}{-LHV_{CO} + 2 * LHV_{H_2}} = \frac{638\frac{KJ}{mol}}{283 + 2 * 242\frac{KJ}{mol}} = 83\% Eq.6$$

Like the direct CO2 hydrogenation route, there is no CO2 produced; additionally, no wastewater is produced either. No energy value is given for the oxygen produced.

Conclusion

The best heating value efficiency to produce methanol is direct CO2 hydrogenation (88%),followed by SMR with hydrogen coproduction(87%), CO2 reduction (83%), SMR using hydrogen as fuel (79%), and coal gasification(67%). The major assumption is that hydrogen, natural gas, coal, and methanol are valued for their fuel value. The energy required to produce the feedstock or dispose of the byproducts are not included. Despite this, SMR dominates the methanol production routes because of the availability of methane (natural gas) and the lack of low-cost hydrogen for CO2routes.

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