IEA AMF TASK 64 WEBINAR, SEP 18TH, 2024

E-FUELS MODELING & TECHNOECONOMIC ANALYSIS

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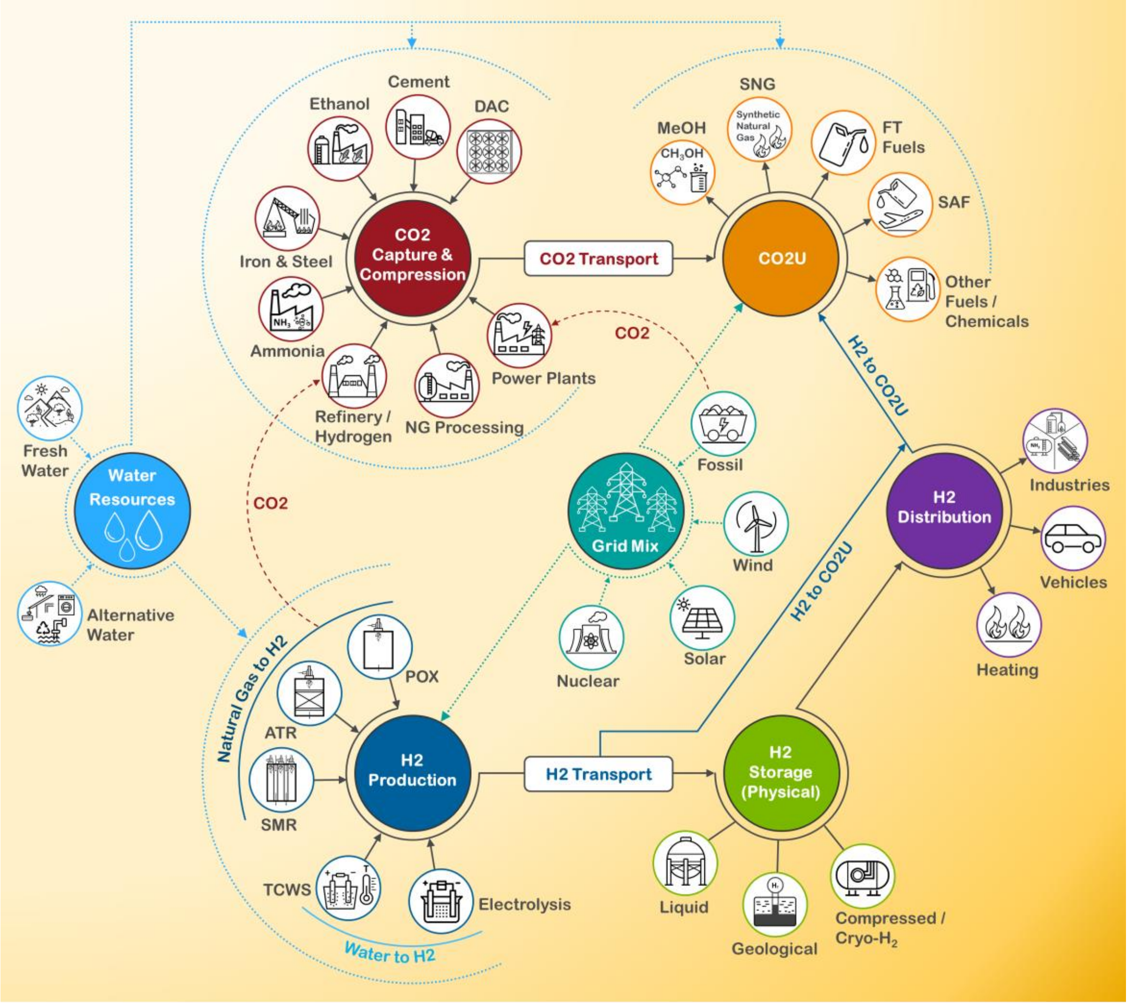
Argonne National Laboratory
U.S.A

E-fuels value chain study- Process modeling, TEA and LCA, supply & market



- We evaluate the full efuels value chain including CCUS and H2 value chains.
- H2 value chain includes production (with/without embodied emission), infrastructure (pure and H2/NG blend), refueling for vehicles and H2 for industrial use.
- CCUS value chain covers capture (from various sources and DAC), infrastructure, utilization for fuels/chemicals/materials, and storage.

- HDSAM for H2 infrastructure
- HCSAM and NH3 infrastructure

https://hdsam.es.anl.gov/
https://www.hydrogen.energy.gov/docs/hydrogenprogramlibraries/pdfs/review24/in025_elgowainy_2024_o.pdf?sfvrsn=14b08ed8_3

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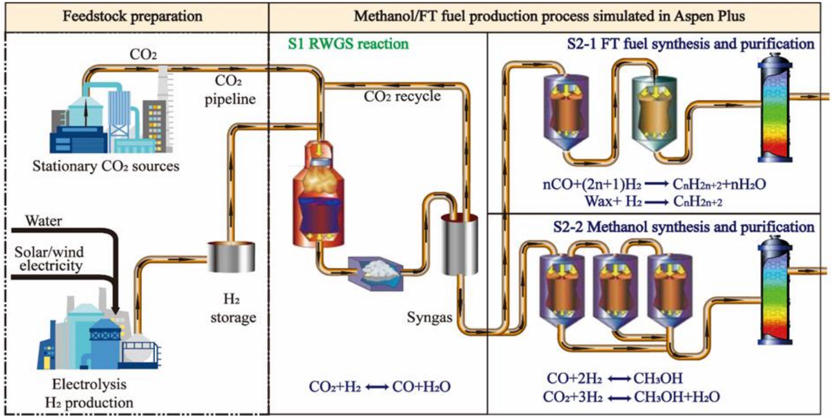
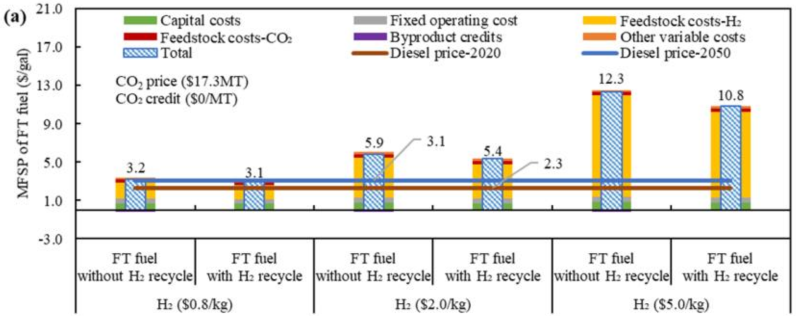
E-FUELS STUDY TOOLS

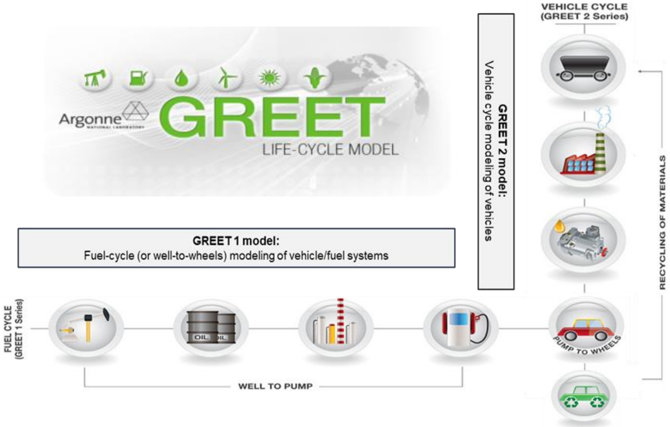
Process and infrastructure modeling



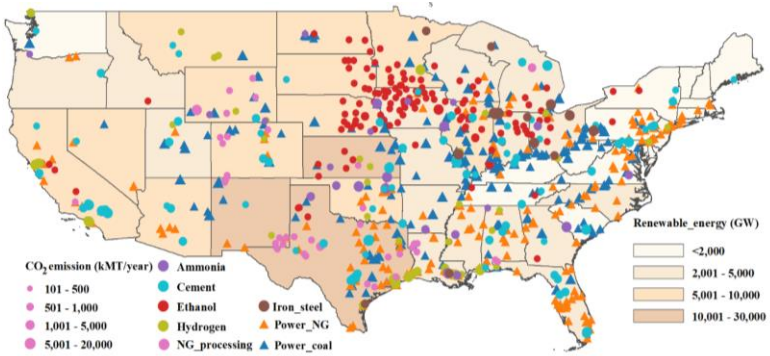
Technoeconomic analysis (TEA) (cost $$)



Life cycle analysis (LCA) by using GREET model



Regional analysis with variation in technology, supply, storage and cost



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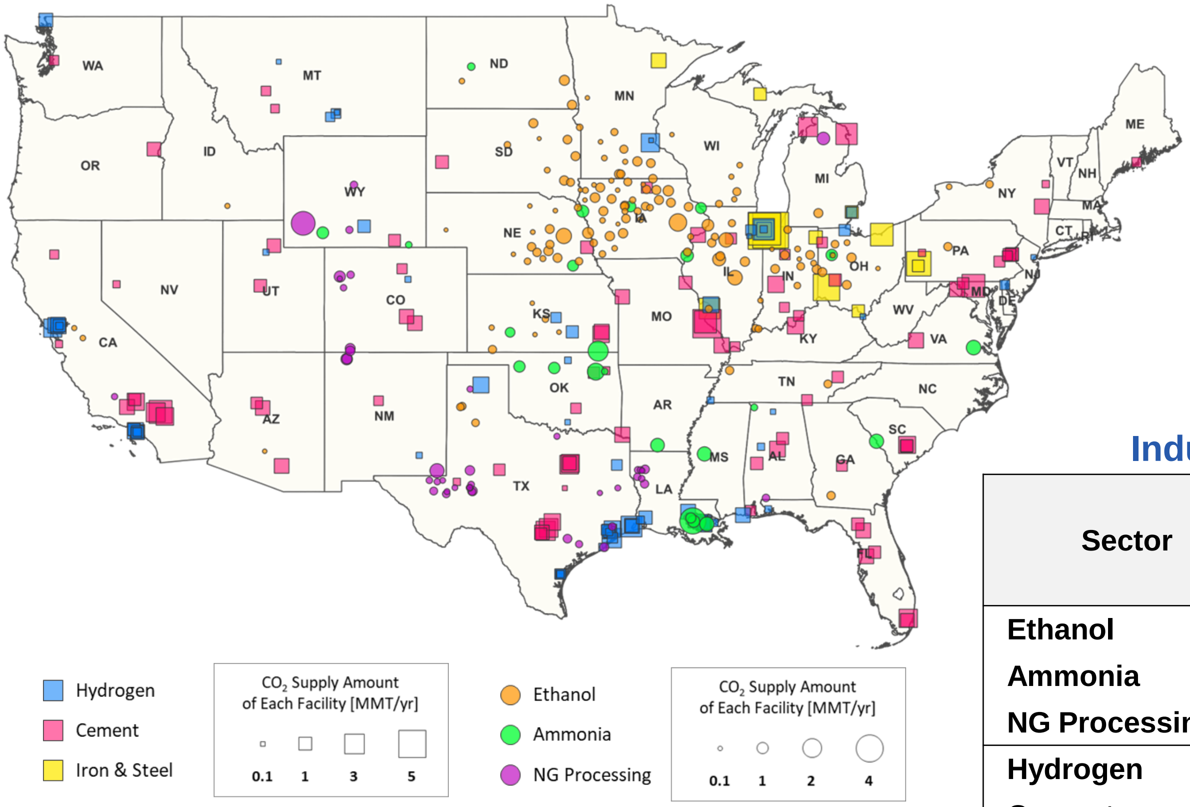
INDUSTRIAL CO2 SOURCE LOCATIONS AND AMOUNTS

Industrial CO_2 Source Distribution in the U.S. (as of now)

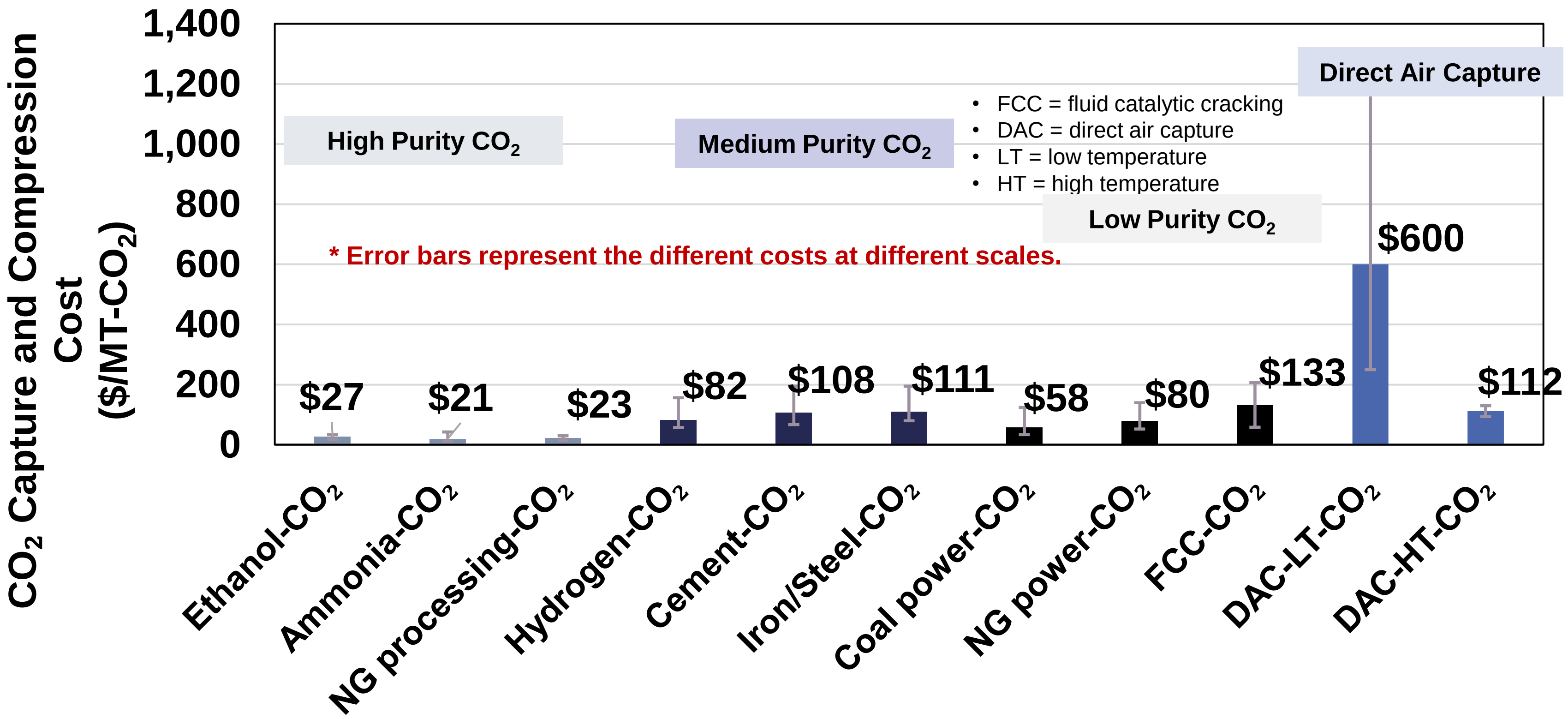


- Industrial sector is the second largest CO_2 emission source, after transportation sector.
- Industrial sector emission is sourced from both process and fuels combustion.
- The CO_2 capture energy demand and cost generally increases with decreasing purity.

Industrial CO_2 Source Data

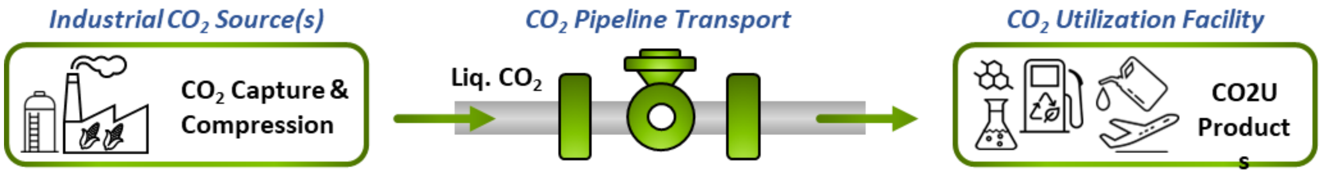
Sector	Purity	# of Plants	Available CO_2 [MMT/yr]
Ethanol	High	136	27
Ammonia	High	26	20
NG Processing	High	44	10
Hydrogen	Mid	74	40
Cement	Mid	89	64
Iron and Steel	Mid	18	37

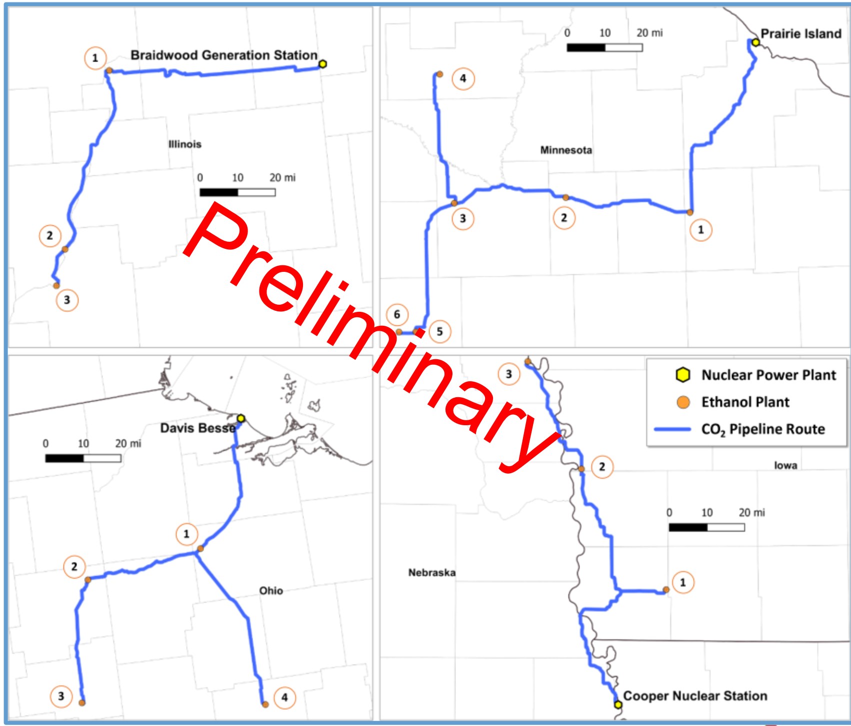
COST OF CO_2 CAPTURE AND COMPRESSION



- The cost of CO2 capture and compression are greatly influenced by purity and process scale.

In-house CO2 pipeline model: to NPP for efuels





- **Target Synfuel Plant Size and CO_2 Demand**
  - **Midwest**: 4 nuclear power plants, utilizing abundant ethanol CO_2
  - **Gulf Coast**: 2 nuclear power plants, utilizing CO_2 from ammonia plants and pulp & paper plants
  - **East Coast**: 3 nuclear power plants, utilizing CO_2 from large scale pulp & paper plants

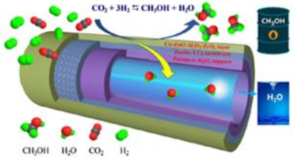
ESTABLISHED E-FUELS MODELING

SAF → Syngas → FT process → Hydro-cracking → Distillation

NH3 → Green H2 and ASU → HB process

SNG → Sabatier

MeOH → One step conversion



MeOH, chemicals and fuels → Syngas → Methanol formation

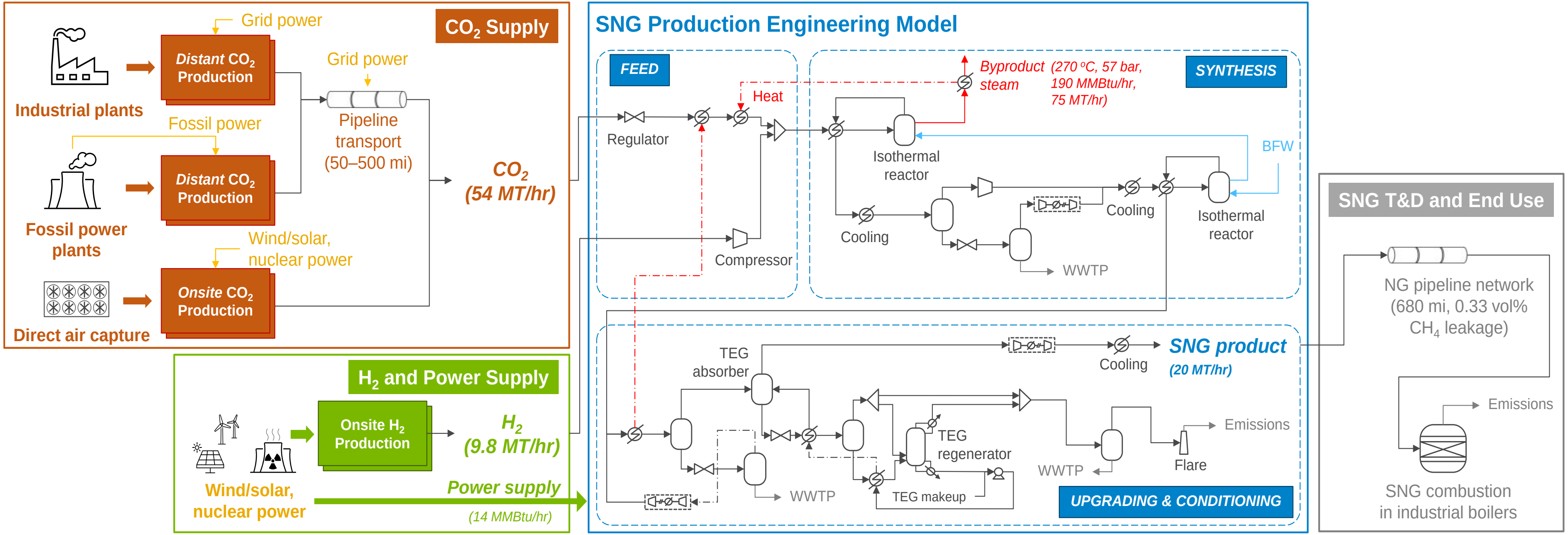
Olefins

Diesel

SNG- PROCESS MODELING

Process modeling of SNG production

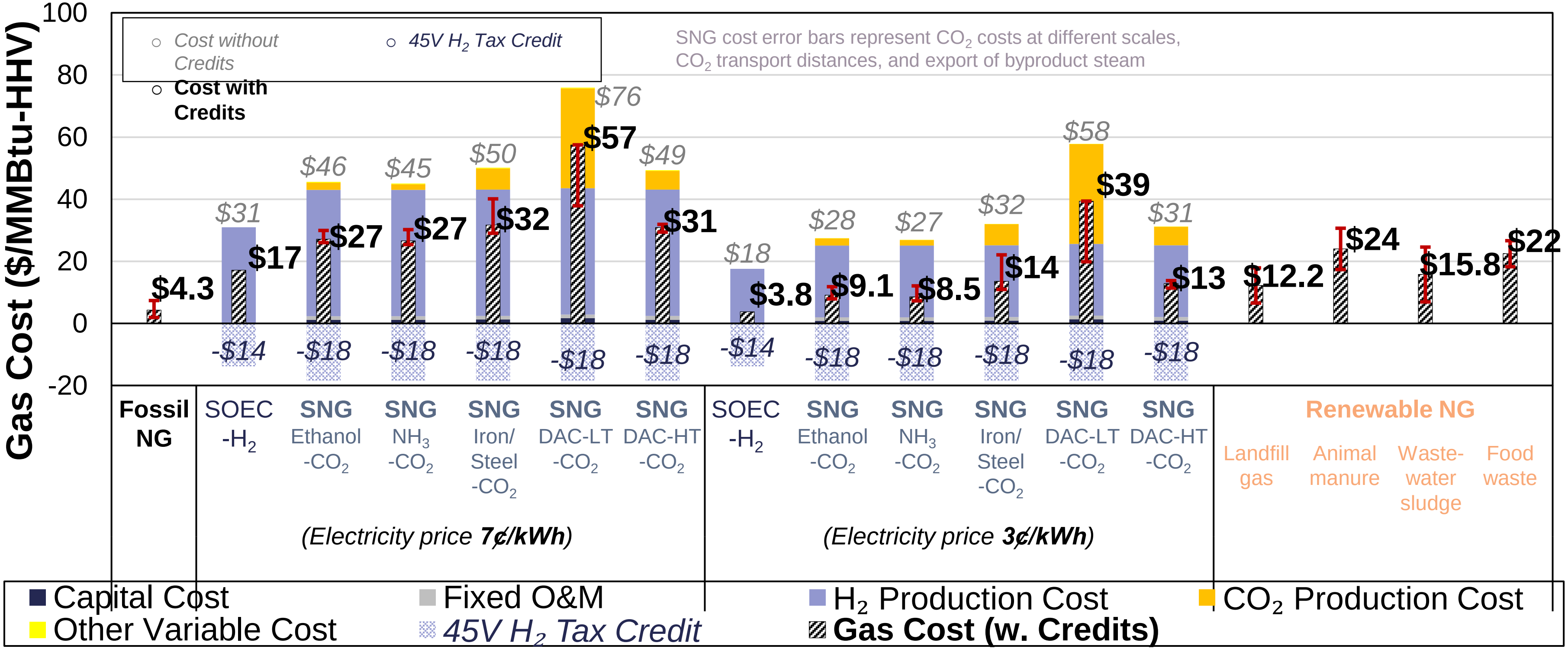
- SNG plant was scaled for a commercial capacity (20 MT/hr), validated in Europe.
- The plant generates 1,020 MMBtu-HHV/hr SNG, 3% of national average NG pipeline throughput, with energy efficiency of 77% (without steam byproduct) and 91% (with steam byproduct)



Techno-economic and life cycle analysis of synthetic natural gas production from low-carbon H2 and point-source or atmospheric CO2 in the United States, K Lee, P Sun, A Elgowainy, KH Baek, P Bobba, Journal of CO2 Utilization 83, 102791

SNG-TECHNOECONOMIC ANALYSIS (TEA)

- SOEC = Solid oxide electrolyzer cell

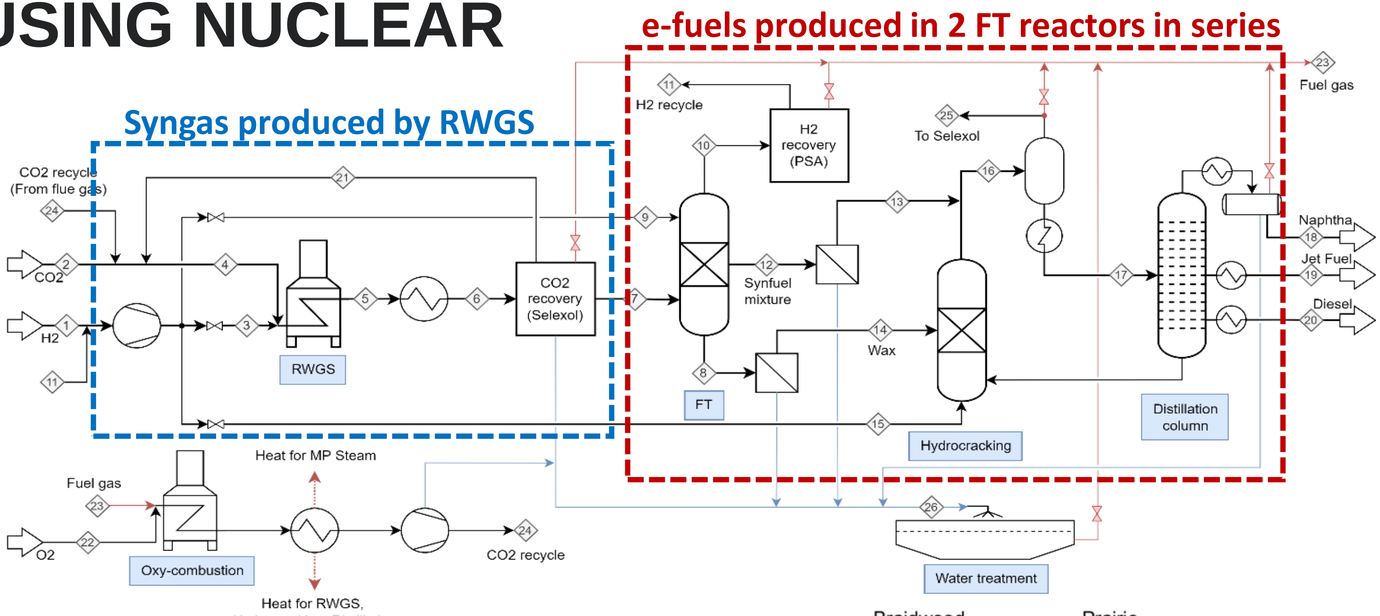


- *H_2 production cost is based on DOE 2020 record, Fossil NG cost is based on EIA data, RNG cost is based on literature*
- ***The SNG product cost with a lower electricity price and 45V H_2 credit** could be comparable to **Fossil NG** and **RNG** cost depending on **CO_2 source***

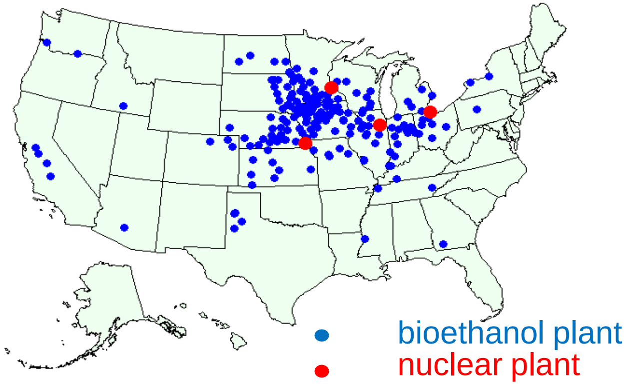
FT E-FUELS USING NUCLEAR

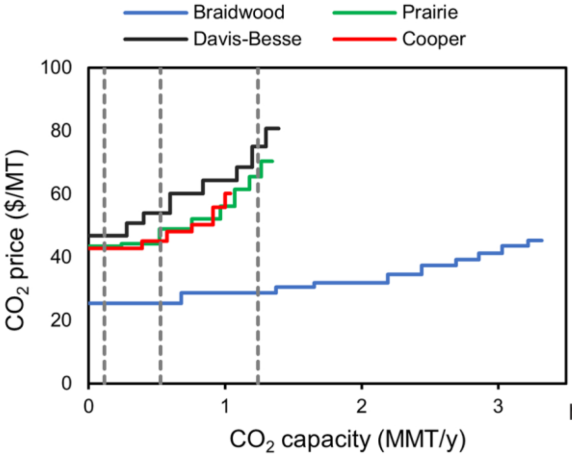
Nuclear energy

- Electricity
- H2
- Heat

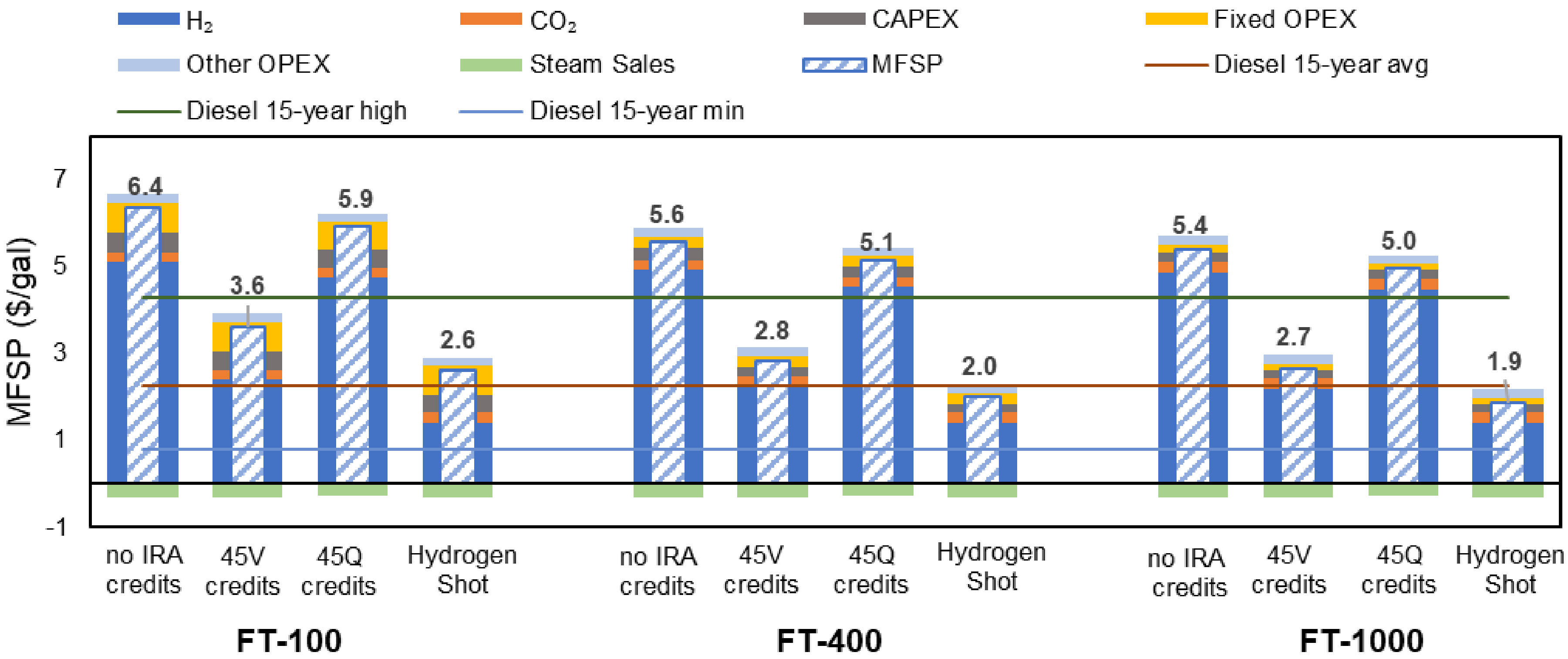


NPP case study:
Braidwood, IL
Prairie, MN
Davis-Besse, OH
Cooper, NE





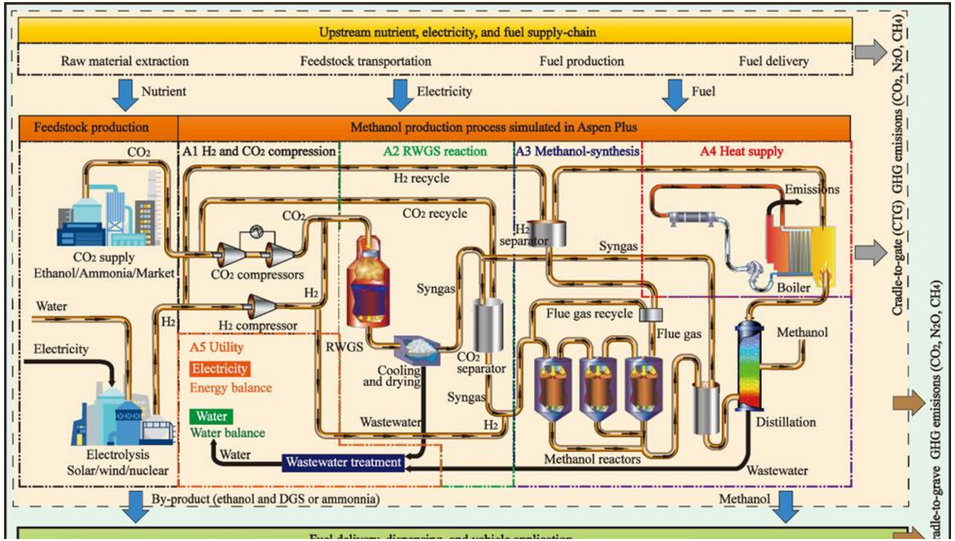
FT FUELS PRODUCTION COST- BRAIDWOOD NUCLEAR

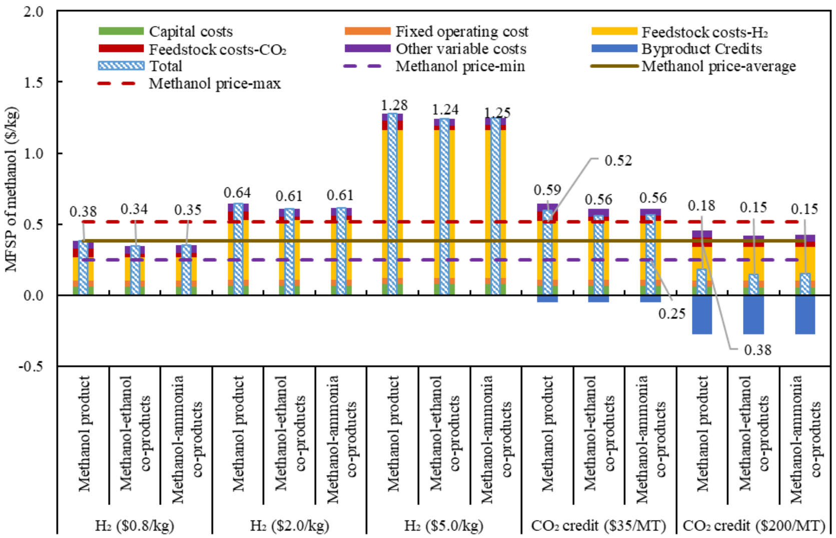


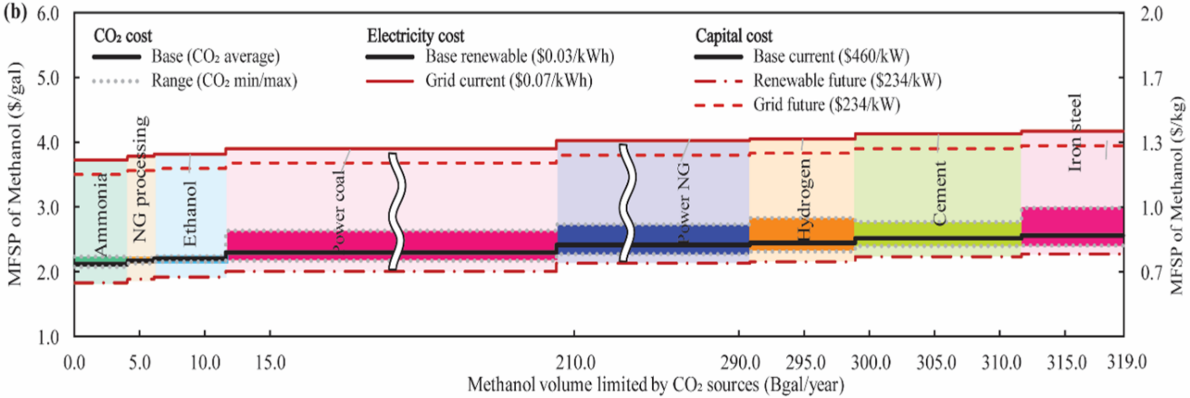
- Hydrogen cost is key cost driver for synfuels production, even with 45 V tax credit.
- The impact of 45Q is smaller than that of 45V using nuclear energy.

Techno-economic analysis and life cycle analysis of e-fuel production using nuclear energy, HE Delgado, V Cappello, G Zang, P Sun, C Ng,, ...Journal of CO2 Utilization 72, 102481

E-fuels -methanol







- E-methanol is of great interest as it is a commodity chemical for various applications, e.g. chemical intermediate, fuels or fuel intermediate, and is easy for transportation.
- U.S. has a great potential for e-methanol production.

G Zang, P Sun, E Yoo, A Elgowainy, A Bafana, U Lee, M Wang, ..Environmental Science & Technology 55 (11), 7595-7604

SUMMARY

- We thank the great support from various DOE offices (HFTO, Nuclear office, ARPA-E, BETO)
- We evaluate various technologies through full value chain of e-fuels, with Aspen modeling of various production technologies (continuous and dynamic operation) and infrastructure modeling
- We develop in-house H_2 infrastructure, NH_3 infrastructure and CO_2 pipeline model.
- For e-fuels production, the key cost driver is H_2 cost. In U.S.A, IRA credit, e.g. 45V has a significant impact.

MORE INFORMATION

Journal of CO2 Utilization 83 (2024) 102791

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Techno-economic analysis and life cycle analysis of e-fuel production using nuclear energy

Hernan E. Delgado [a], Vincenzo Cappello [a], Guiyan Zang [a], Pingping Sun [a,*], Clarence Ng [a]

Journal of CO2 Utilization 46 (2021) 101459

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Performance and cost analysis of liquid fuel production from H_2 and CO_2 based on the Fischer-Tropsch process

Guiyan Zang *, Pingping Sun, Amgad A. Elgowainy, Adarsh Bafana, Michael Wang

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Technoeconomic and Life Cycle Analysis of Synthetic Methanol Production from Hydrogen and Industrial Byproduct CO_2

Guiyan Zang,* Pingping Sun, Amgad Elgowainy, and Michael Wang

Environmental Science & Technology

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Synthetic Methanol/Fischer–Tropsch Fuel Production Capacity, Cost, and Carbon Intensity Utilizing CO_2 from Industrial and Power Plants in the United States

Guiyan Zang,* Pingping Sun, Eunji Yoo, Amgad Elgowainy, Adarsh Bafana, Uisung Lee, Michael Wang, and Sarang Supekar

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Techno-economic performances and life cycle greenhouse gas emissions of various ammonia production pathways including conventional,

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Blending low-carbon hydrogen with natural gas: Impact on energy and life cycle emissions in natural gas pipelines

Vincenzo Cappello *, Pingping Sun, Amgad Elgowainy

THANK YOU!

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