PerspECCtive

INSPIRING Change, Leaders, and Innovation

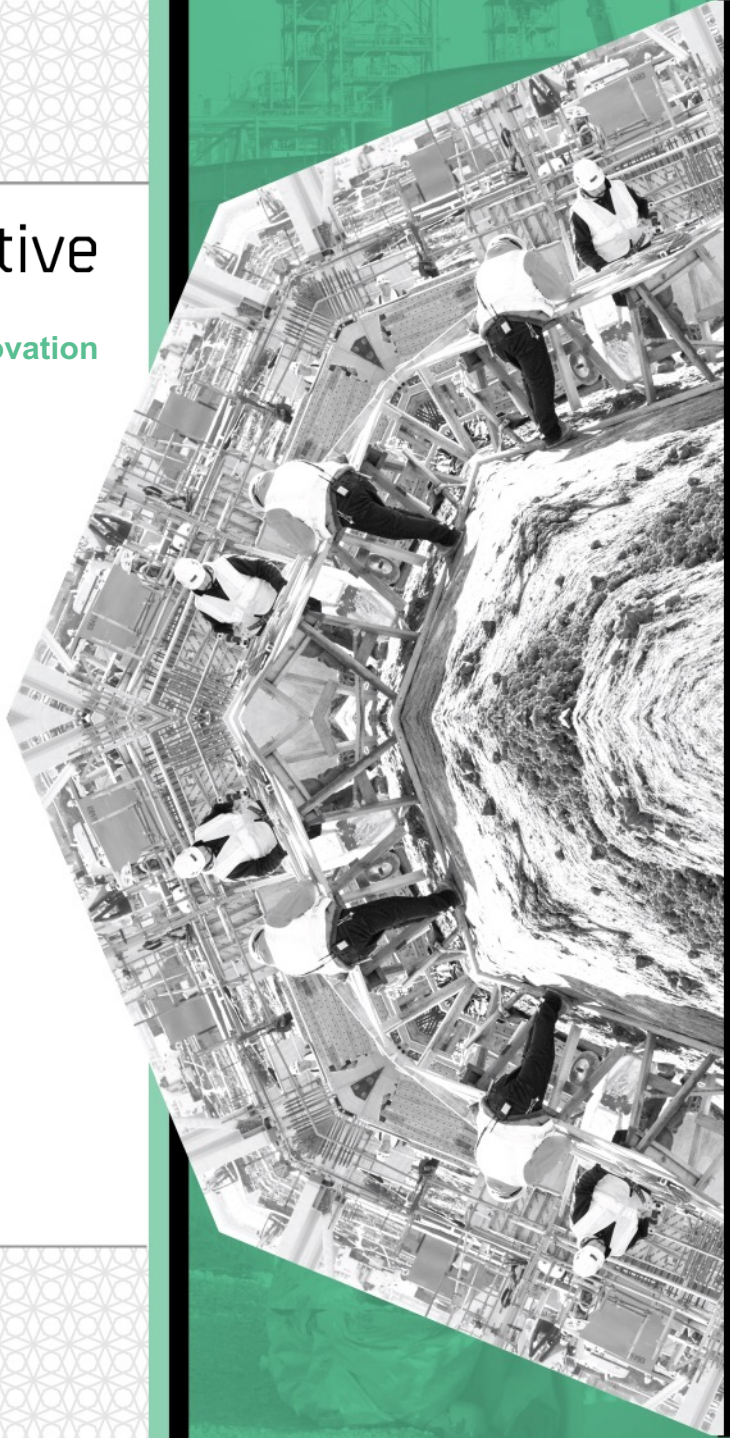
Our Low Carbon Future

Future Leader Forum

September 8-9, 2022

San Antonio, TX

ECC



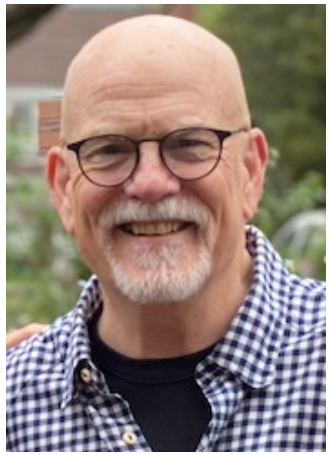
Our Low Carbon Future

Facilitator

Thomas Bereswill

Project Lead Big Data/Sustainability
BASF

Panel Members



Kyle Simpson

Principal
KSE Holdings LLC

Dr. Paul Schubert

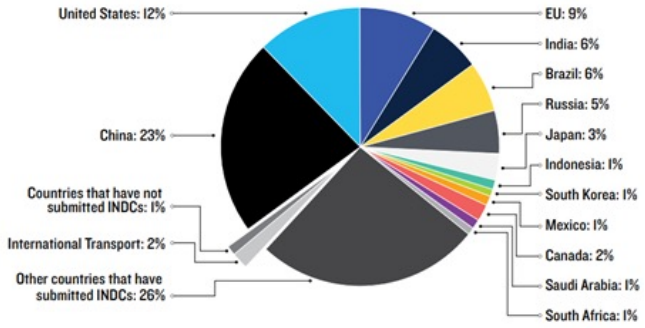
CEO
Strategic Biofuels LLC

Alex Brayton

Senior Process Engineer
Technip Energies

Our Low Carbon Future

Paris Climate Agreement



1. Limit Global Temperature Rise

- ❑ Reducing Greenhouse Emissions economy-wide
- ❑ Adapting to unavoidable impacts

2. Commitment from the US

- US is the 2nd largest emitter
- 50-52% reduction over 2005 by 2030
- “Carbon-pollution” free power by 2035
- Net zero by 2050

3. Provides a Framework

- There are some mandatory measures
- Countries to allocate financial assistance
- Technology development and transfer
- Developing country capacity-building
- No financial penalties, motivation by peer pressure

4. Paris Agreement Cost

- Generally agreed framework to cap / reduce emissions across 196 countries
- $3B direct contribution pledged by US
- Significant public and private emission control and climate adaptation costs

5. Steps from US Corporate

- Shareholder, consumer, and public sector pressure activating large companies to act

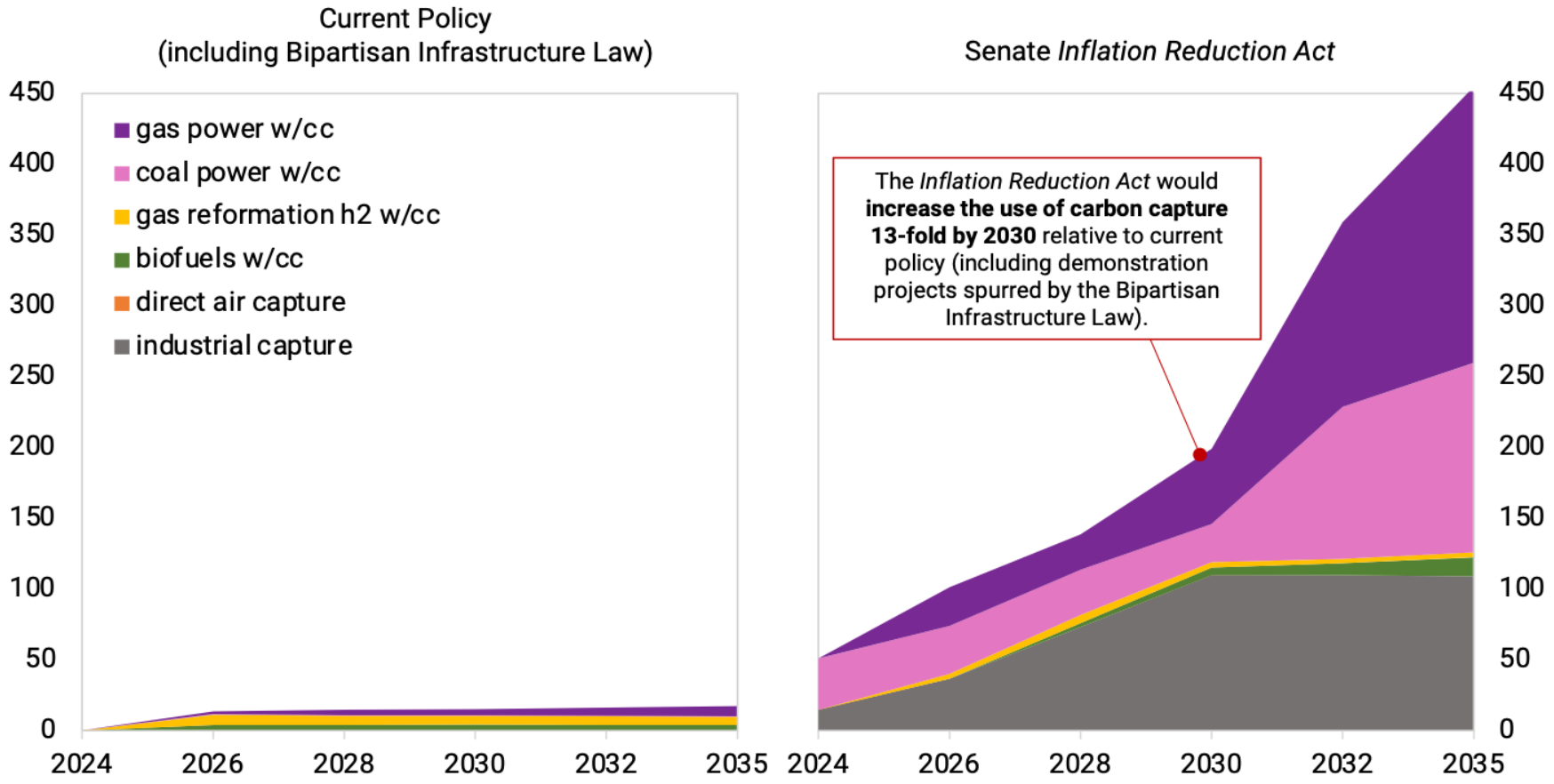
6. Chemical Industry – Carbon Management

- Switching to Renewable Energy sources
- Power-to-steam
- New Technologies
- Continuous Improvement
- Bio-based feedstock

Paris Climate Agreement: Everything You Need to Know | NRDC
NRDC: The Paris Agreement on Climate Change (PDF)

Our Low Carbon Future

Annual carbon dioxide captured for transport and geologic storage (million tons per year)



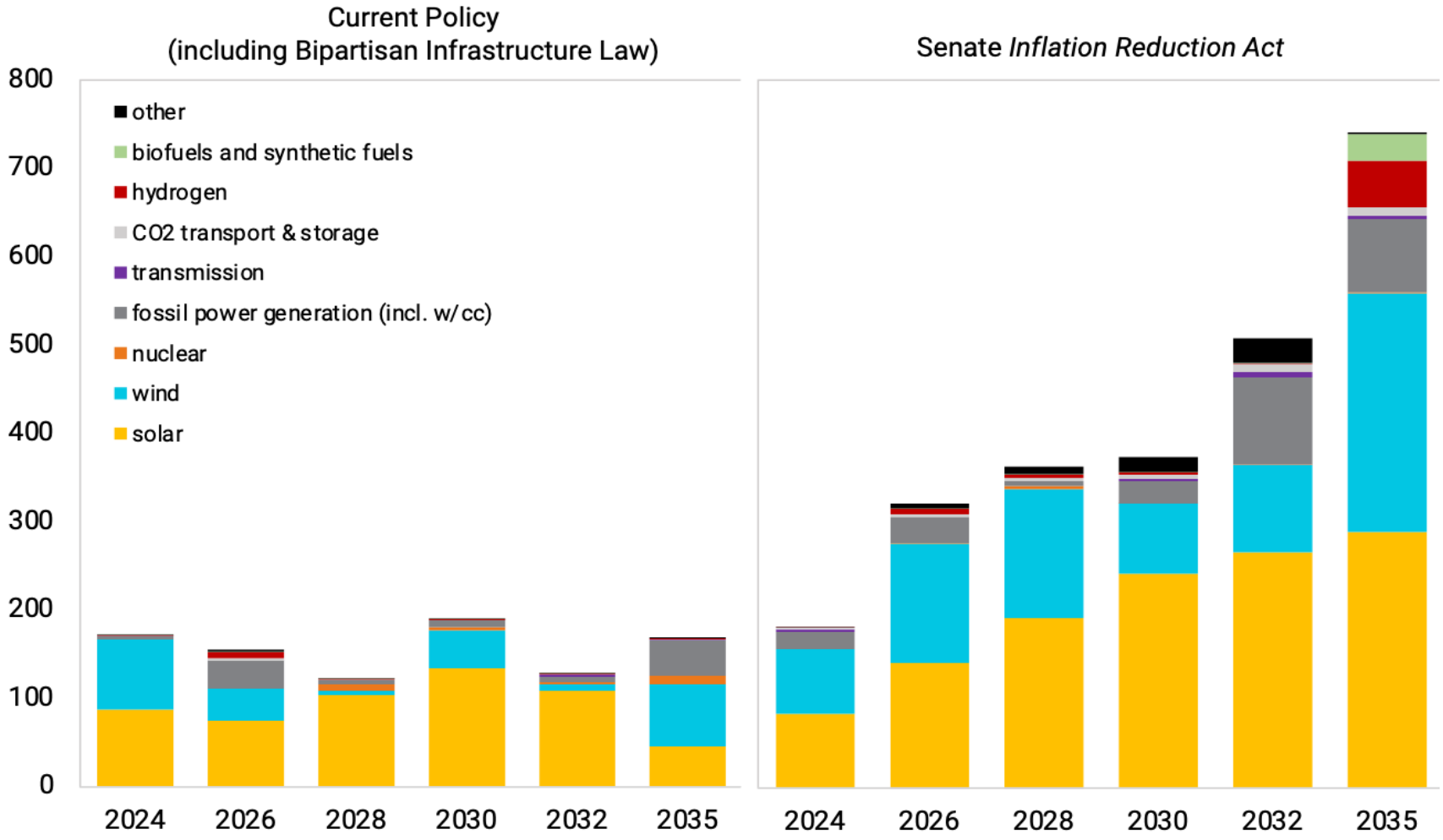
- The Inflation Reduction Act (IRA) makes carbon capture a viable economic option.
- The IRA will drive a 13-fold increase in the use of carbon capture by 2030.
- It is estimated that there will be mode than 200 million tons per year of CO2 capture by 2030.

1 – Courtesy of the REPEAT Project (Rapid Energy Policy Evaluation and Analysis Toolkit)
2 – Growth in annual CO2 injection capacity in storage basins is likely to constrain the pace of carbon capture deployment. This modeling assumes maximum annual CO2 injections increase to 200 Mt CO2/y by 2030 based on expert input and Princeton *Net-Zero America* study.
3 – Industrial CO2 capture volumes are fixed exogenously based on analysis in Larson et al., 2021, "Capturing the Moment: Carbon Capture in the American Jobs Plan," Rhodium Group, April 2021. Carbon capture in fuels conversion (biofuels, hydrogen, ammonia) and power generation are optimized in RIO modeling, constrained by remaining available injection volume limit.

Our Low Carbon Future

Annual capital investment in energy supply related infrastructure (billion 2018 USD per year)

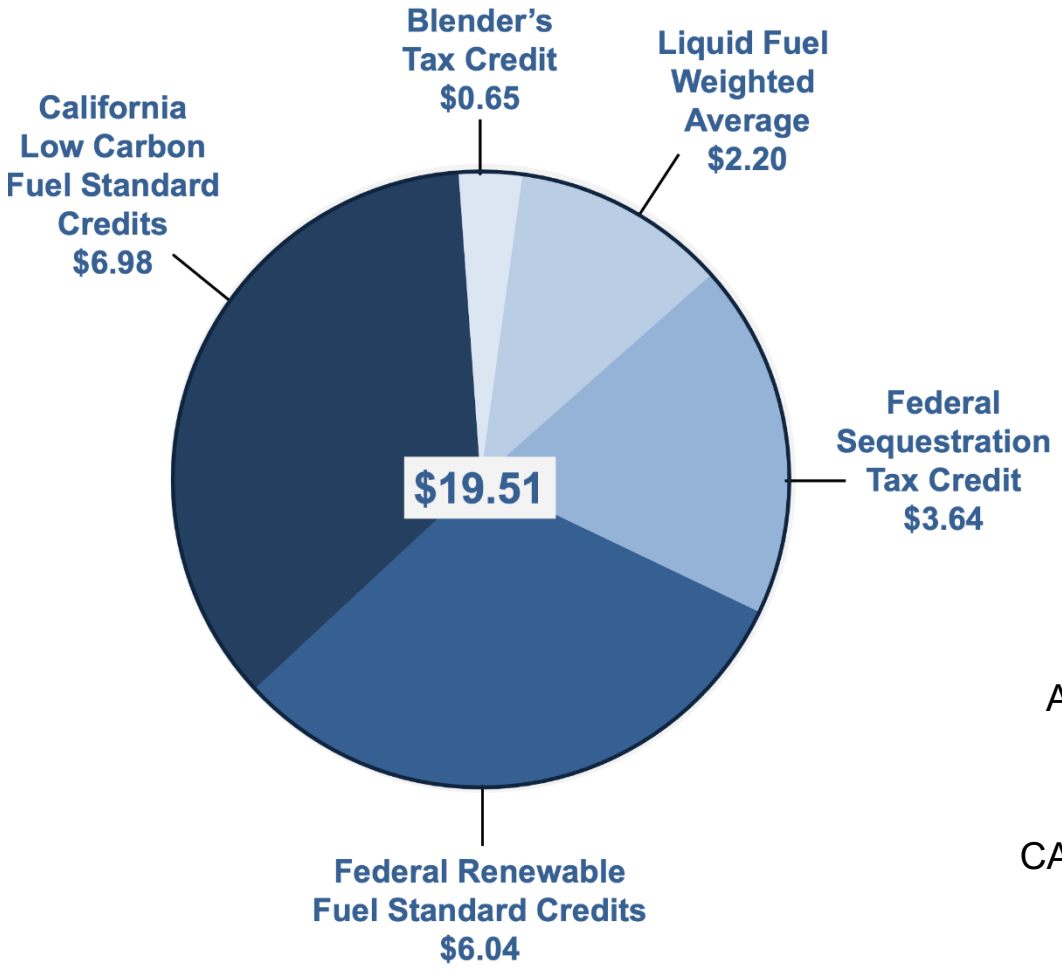
- The Inflation Reduction Act (IRA) will drive nearly $3.5 trillion in capital investment by 2032.
- That includes $20 billion per year in CO2 capture, utilization and storage by 2030.
- Annual investment in hydrogen increases to $3 billion by 2030 and over $50 billion by 2035.



*Courtesy of the REPEAT Project (Rapid Energy Policy Evaluation and Analysis Toolkit)

LOUISIANA GREEN FUELS PLANT PROJECT REVENUES AND PRODUCTION COSTS

Revenues are highly dependent on compliance with regulatory program

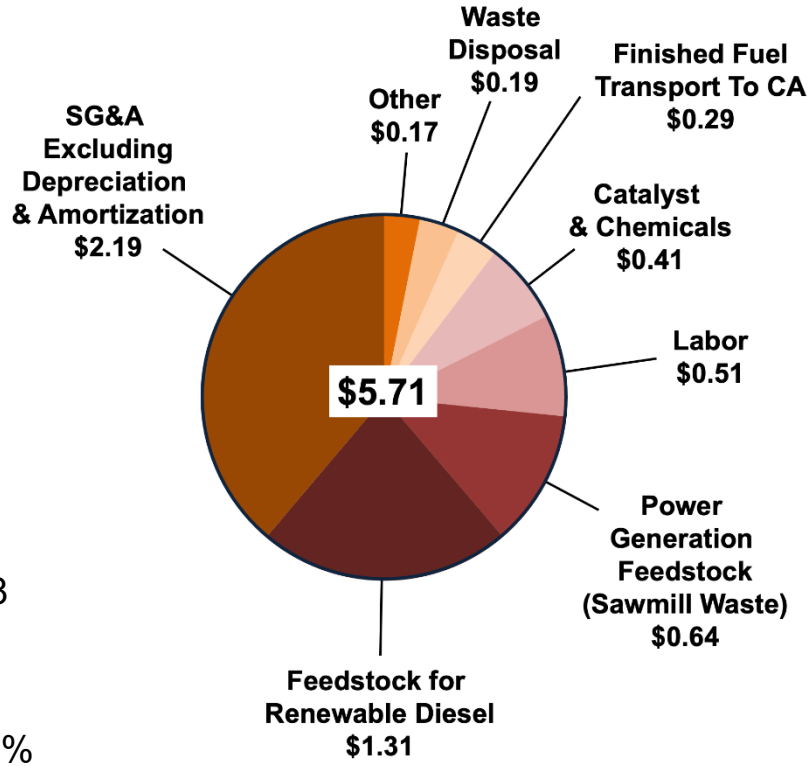


Assumptions

Argus Forecast for 2028
RFS (RINS) = $3.80
LCFS = $160

CARB Buffer Account 7.9%

CARB Diesel = $2.24
CA Naphtha = $1.90
45Q = $85/ton



Our Low Carbon Future

Discussion Topics

1. Carbon Capture Technology Readiness
2. Hydrogen – Justification, Pros/Cons, Colors?!
3. Biofuels – Types, Feedstock, Issues To Consider
4. CO2 Sequestration Challenges
5. Enhanced Oil Recovery – Pros/Cons…Tied to Biofuels?!
6. CO2 Utilization
7. Environmental Justice

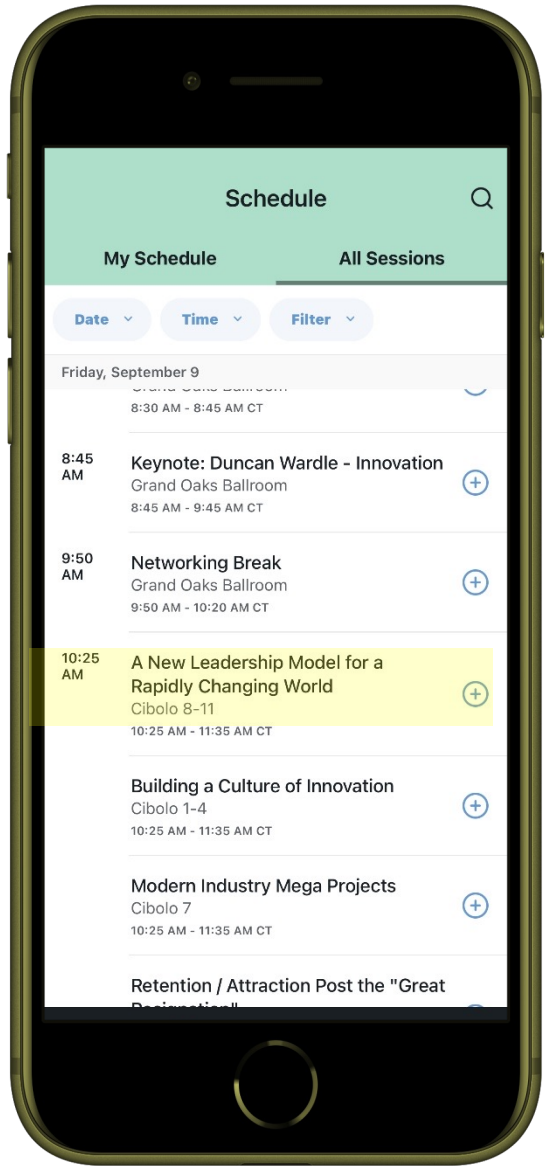
Live Polling

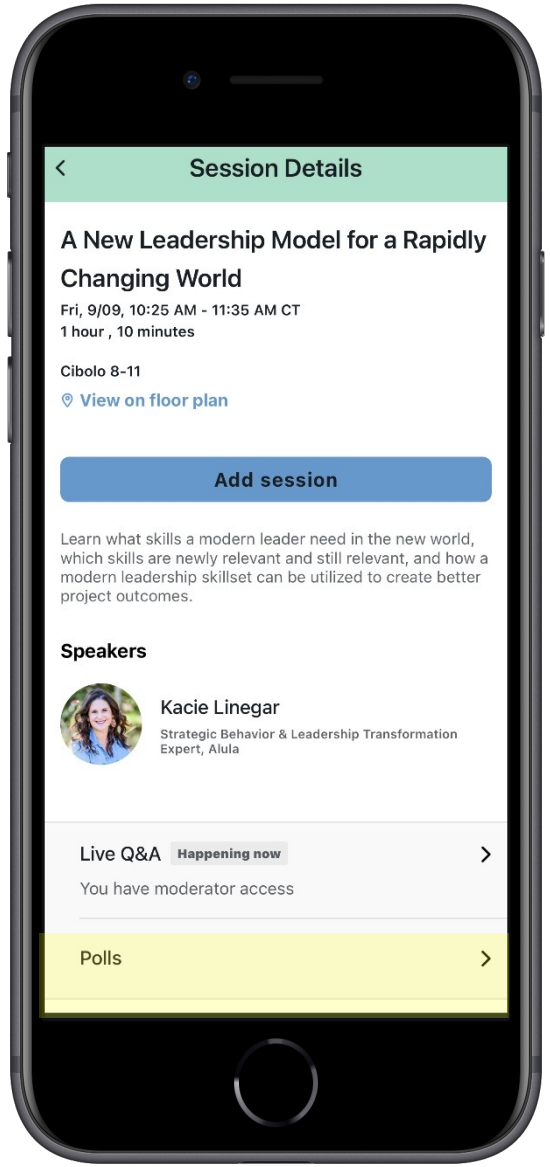
Open the Conference App (CVENT)

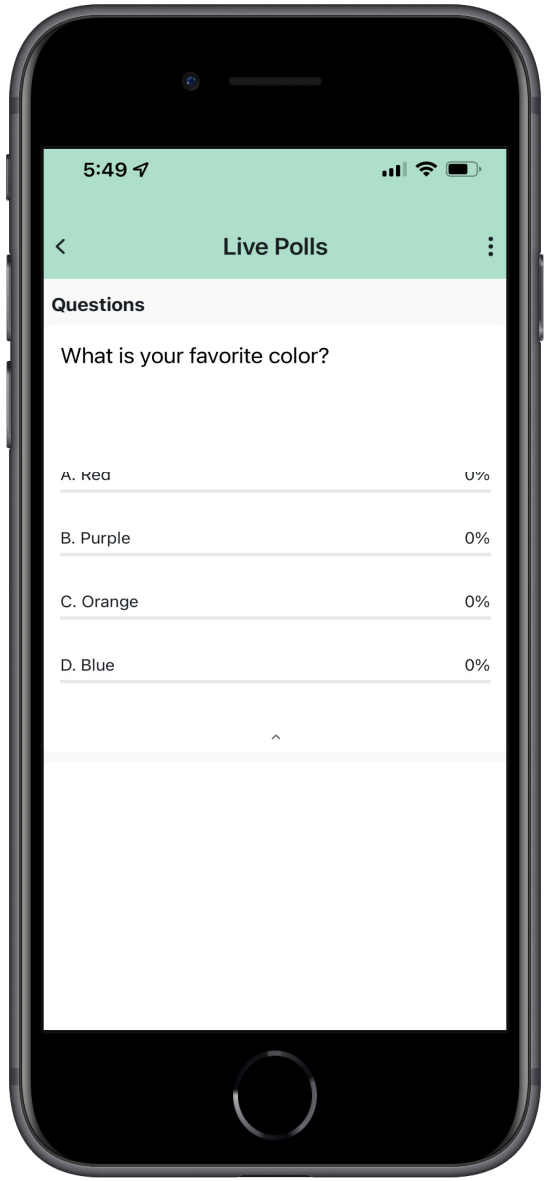
1 Navigate Go to the **session** you are attending.

2 Click Polls Click “Polls” option which will open up the questions for that session

3 Answer. One question will be available to answer at a time * a moderator or AV tech will open and close questions during the session as needed for sessions with more than one live poll question.







Our Low Carbon Future

CO_2 Capture Technology Readiness

DEVELOPMENT YEAR	1930 – 40s	1950 – 60s	1970 – 90s
CO_2 Capture Technology	Liquid Solvents (Amine / Physical)	Solid Adsorbent	Membrane
CO_2 Capture (%)	90% - 98%	90%	70 – 95%
Capture Cost	Low	Moderate	Moderate
Plot Space	High	Moderate	High
Technology Readiness	Commercialized (Mature)	PSA – Commercialized TSA – Large pilot testing	Commercial Pilot / Demo
Key Projects	SaxsPower Boundary Dam, Petra Nova	Air Products Port Arthur	Petrobras Santos Basin

- **Capture Approaches:** Post-combustion, Pre-Combustion, Oxy Combustion, Direct Air Capture

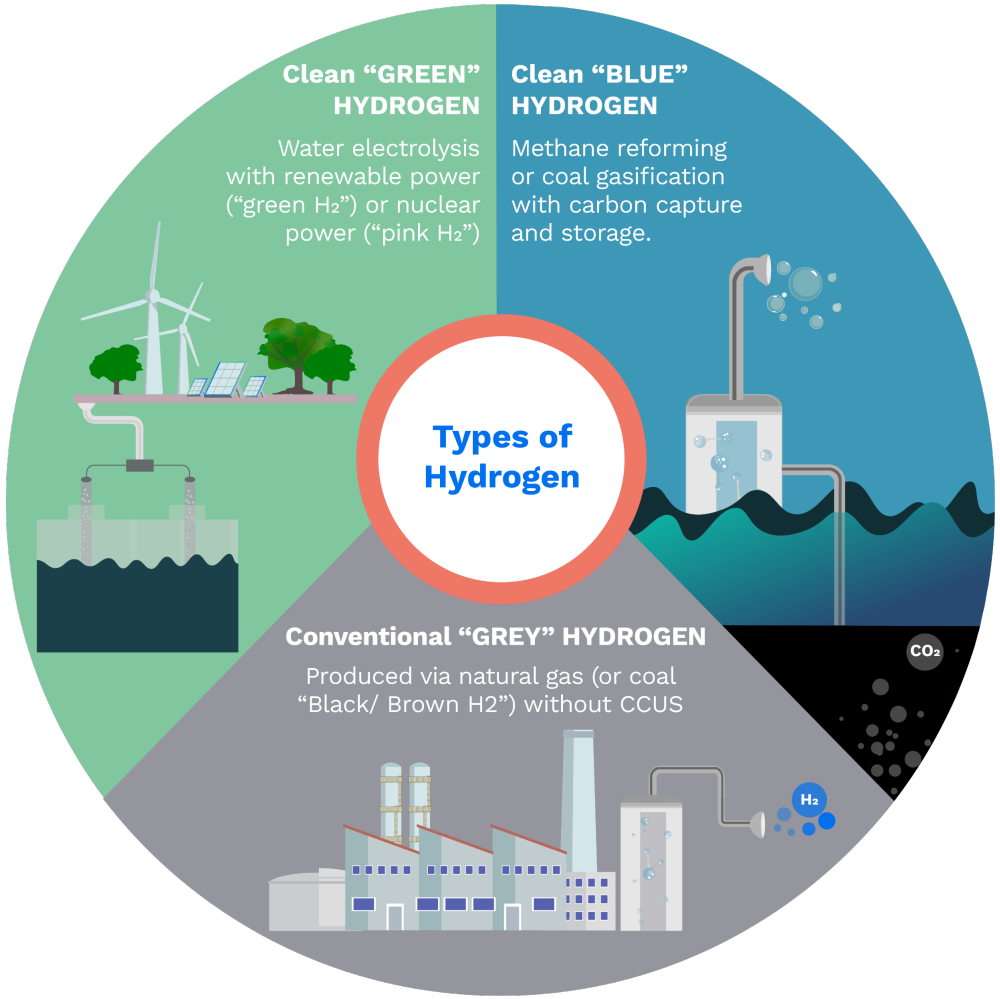
Source: Global CCS Institute, “Technology Readiness and Costs of CCS” (March 2021).

Our Low Carbon Future

Hydrogen – Justification, Pros/Cons, Colors?!

$$2H_2 + O_2 \rightarrow 2H_2O + \text{Heat}$$

- H_2 = clean fuel for hard to decarbonize sectors
  - Pros: Versatile (fuel, energy storage/carrier, feedstock)
  - Cons: Storage / low energy density, safety
- Colors of Hydrogen
  - Gray, Blue, Green and More
- "Clean" Hydrogen Policy
  - Infrastructure Investment and Jobs Act (2021) - $9.5 b
  - Inflation Reduction Act (2022) - $3/kg for Clean H2



Source: Technip Energies

Our Low Carbon Future

Hydrogen – Cost and Demands

Levelized Cost of Hydrogen

Green H_2 (2020) = $5 / kg

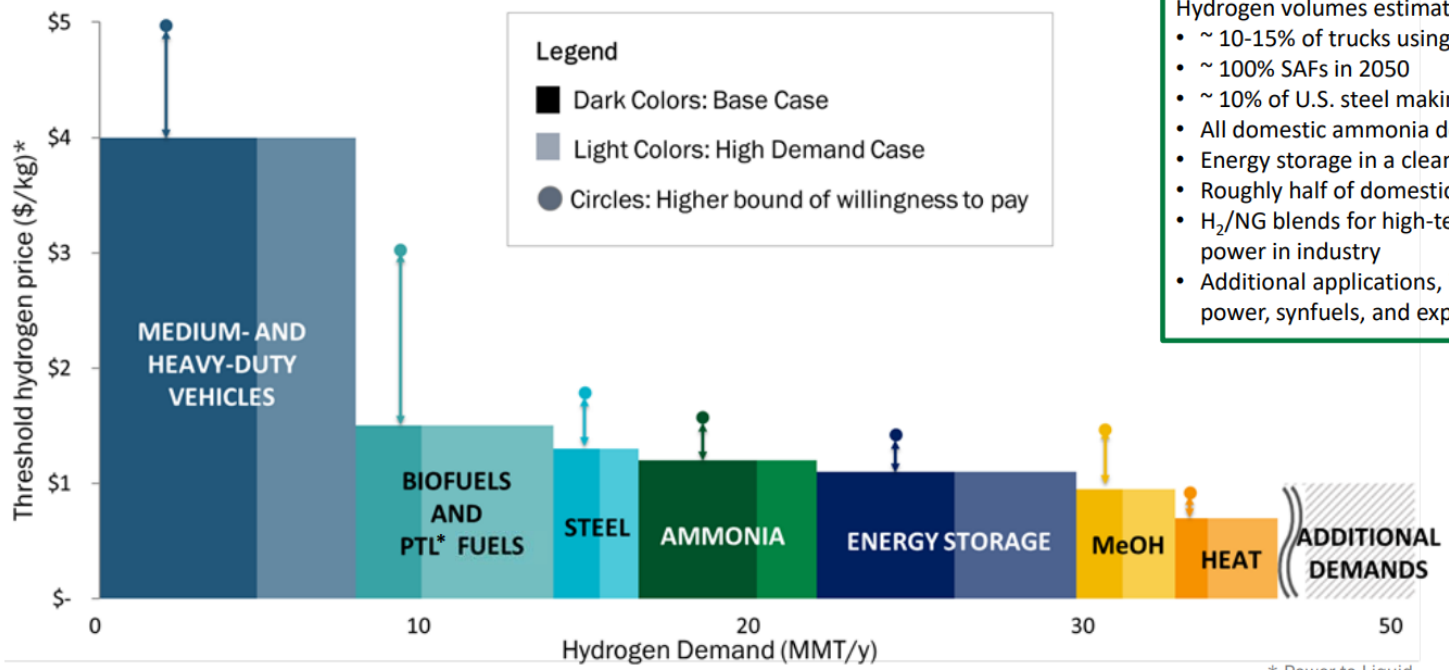
IRA

❖ *$3/kg Credit for Clean H_2*

Green H_2 (2022) = $2 / kg

Blue H_2 (2020) = ~$1.5 / kg

Clean Hydrogen Demand and Costs for Market Penetration



Scenario Analyses for H_2 Demand**

Hydrogen volumes estimated for:

- ~ 10-15% of trucks using fuel cells
- ~ 100% SAFs in 2050
- ~ 10% of U.S. steel making
- All domestic ammonia demand
- Energy storage in a clean grid
- Roughly half of domestic methanol
- H_2/NG blends for high-temp heat and power in industry
- Additional applications, include stationary power, synfuels, and export potential

Costs include production, delivery, dispensing to the point of use (e.g., high-pressure fueling for vehicle applications)

* Power to Liquid

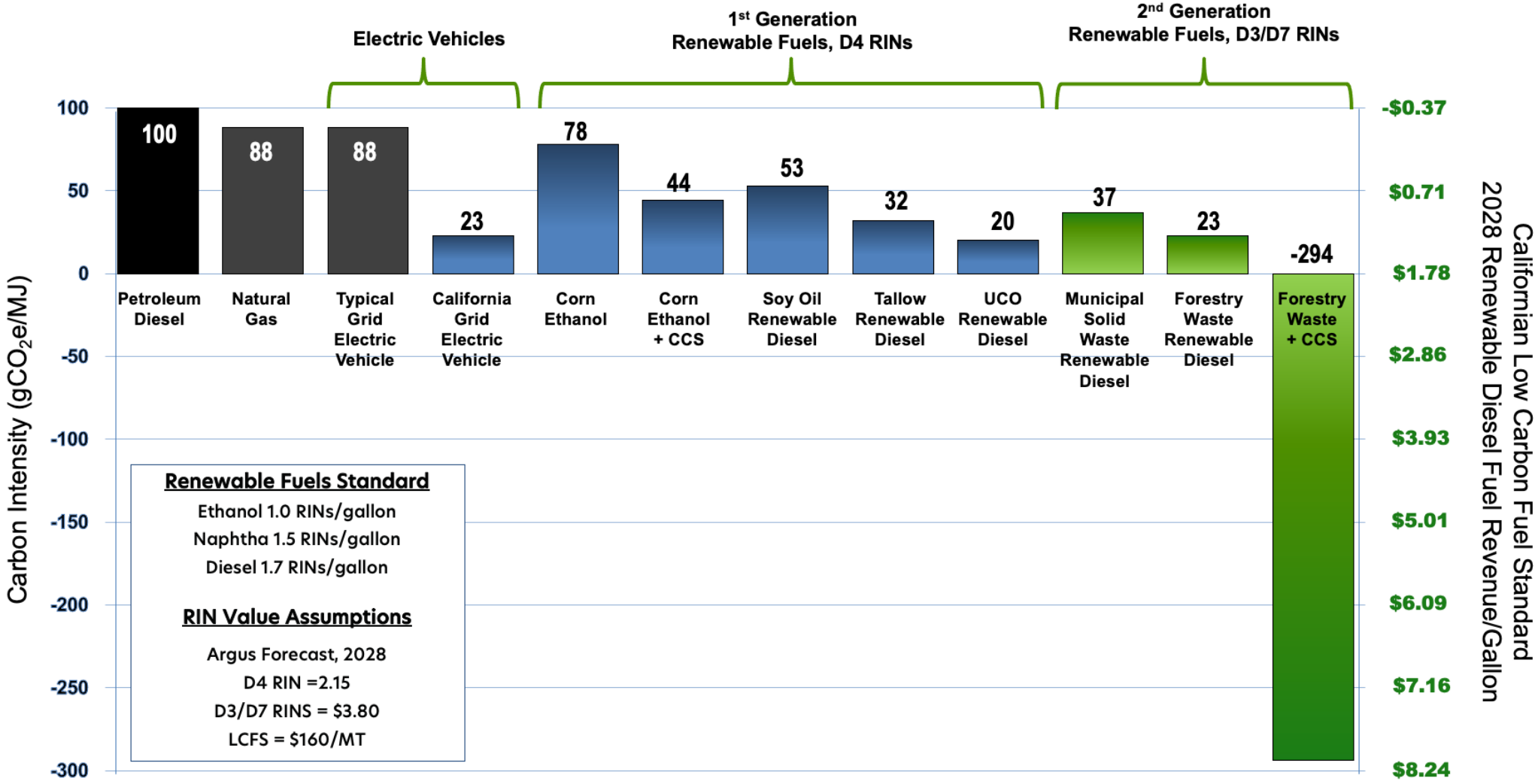
** Volumes dependent on multiple variables

Green H_2 = PEM electrolysis

Blue H_2 = SMR + CCS

Source: US DOE, Hydrogen and Fuel Cell Technologies Office, “2022 AMR Plenary Session”.

Our Low Carbon Future
Biofuels – Types, Feedstock, Issues To Consider



Our Low Carbon Future

CO_2 Utilization

	Direct CO_2 Utilization		CO_2 to Chemicals/Fuels		CO_2 to Materials
CO_2 Utilization Pathway	EOR / Sequestration	Urea	Methanol	Bio-Ethanol	Aggregates
Production Process	CO_2 Compression	Thermal Conversion	Catalytic Conversion	CO_2 Fermentation	Mineralization
Yield per kTA of CO_2 Feedstock	1 kTA CO_2	1.3 kTA Urea	0.6 kTA methanol	0.5 kTA ethanol	10.5 kTA aggregate
Hydrogen Required?	No	No	Yes	Yes	No
ISBL CAPEX	Low	Moderate	Moderate	High	Moderate
Plot Space	Low	Moderate	Moderate	High	High
Technology Readiness	Commercialized	Commercialized	Commercial Pilot / Demo	Commercial Pilot / Demo	Commercial Demonstration

Our Low Carbon Future

Environmental and Social Justice Impact

- **Environmental Justice:** focusing on waste and pollution, resource depletion. greenhouse gas emission, deforestation, climate change and their impact on disadvantaged groups.
- **Social Justice:** concentrates on employee relations & diversity, working conditions, local communities, seeks explicitly to fund projects or institutions that will serve poor and underserved communities globally, health and safety, and conflict.
- **Practical Implementation on a Project: Louisiana Green Fuels Project**
  - **Project Site: Port of Columbia, Caldwell Parish, LA**
    - No negatively impacted disadvantages groups
    - **Economic impact -** 7th poorest US Congressional District - $36,000/yr avg household income
      - 151 direct full-time positions @ $68,000/yr
      - 750+ indirect full-time jobs
      - 635 construction jobs with a peak of 1500
      - >50% Increase in the Parish's tax base
    - **Educational impact**
      - STEM program created in Caldwell Parish Schools (Jan 2022)

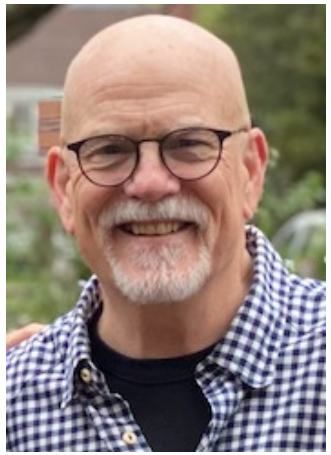
Our Low Carbon Future

Facilitator

Thomas Bereswill

Project Lead Big Data/Sustainability
BASF

Panel Members



Kyle Simpson

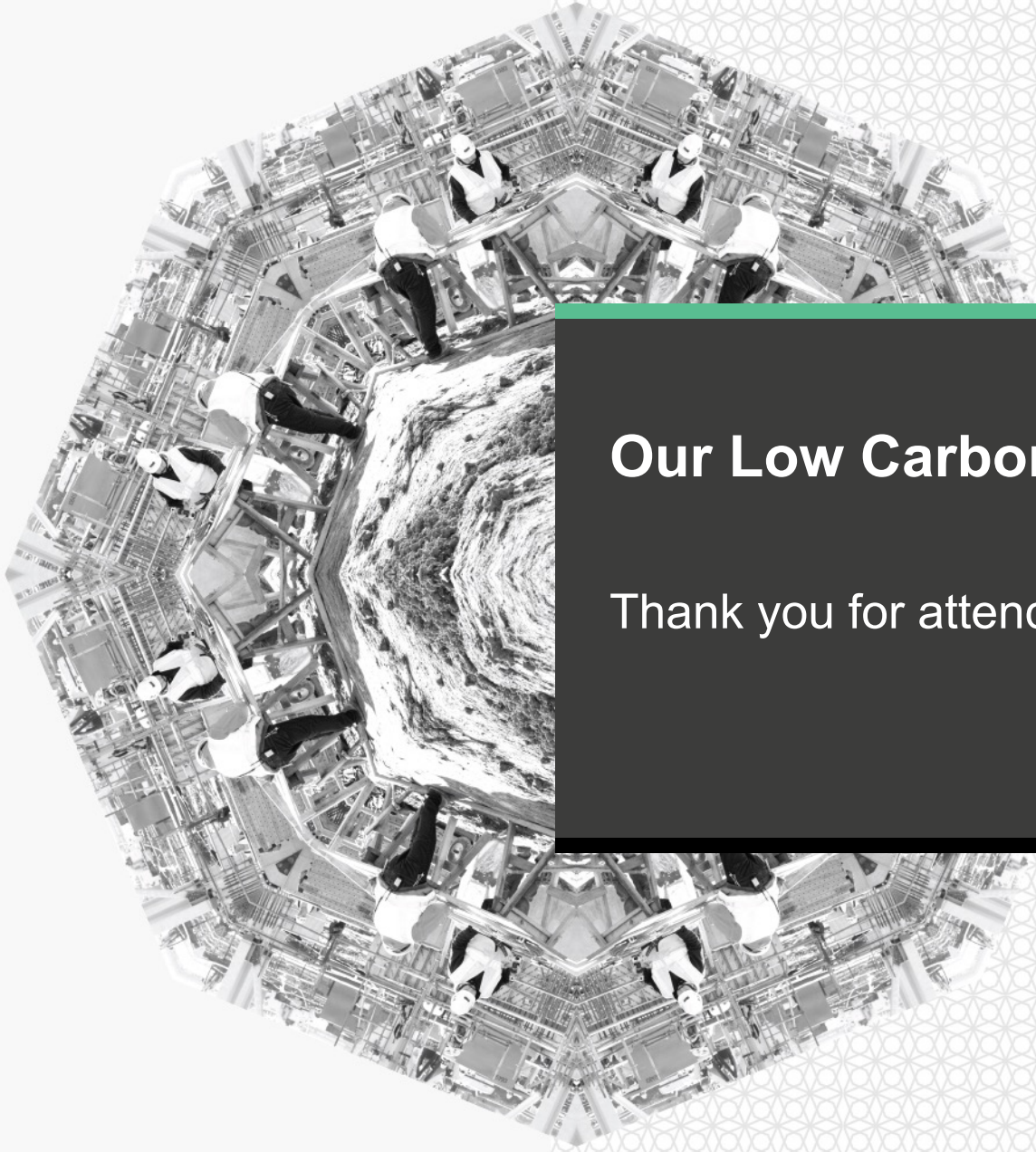
Principal
KSE Holdings LLC

Dr. Paul Schubert

CEO
Strategic Biofuels LLC

Alex Brayton

Senior Process Engineer
Technip Energies



Our Low Carbon Future

Thank you for attending!