



# UNLOCKING THE FUTURE OF HYDROGEN AND E- FUELS

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## Purpose of This Presentation

Global net-zero targets need practical solutions beyond electrification.



Hydrogen and e-fuels offer a path forward for hard-to-abate sectors.



This presentation addresses

"How ready are we?"

"What's blocking us?"

"Where do we go next?"



## Burning Questions in Front of Us



What are the techno-economic realities of hydrogen and e-fuels?



Which parts of the value chain are mature, and which are not?

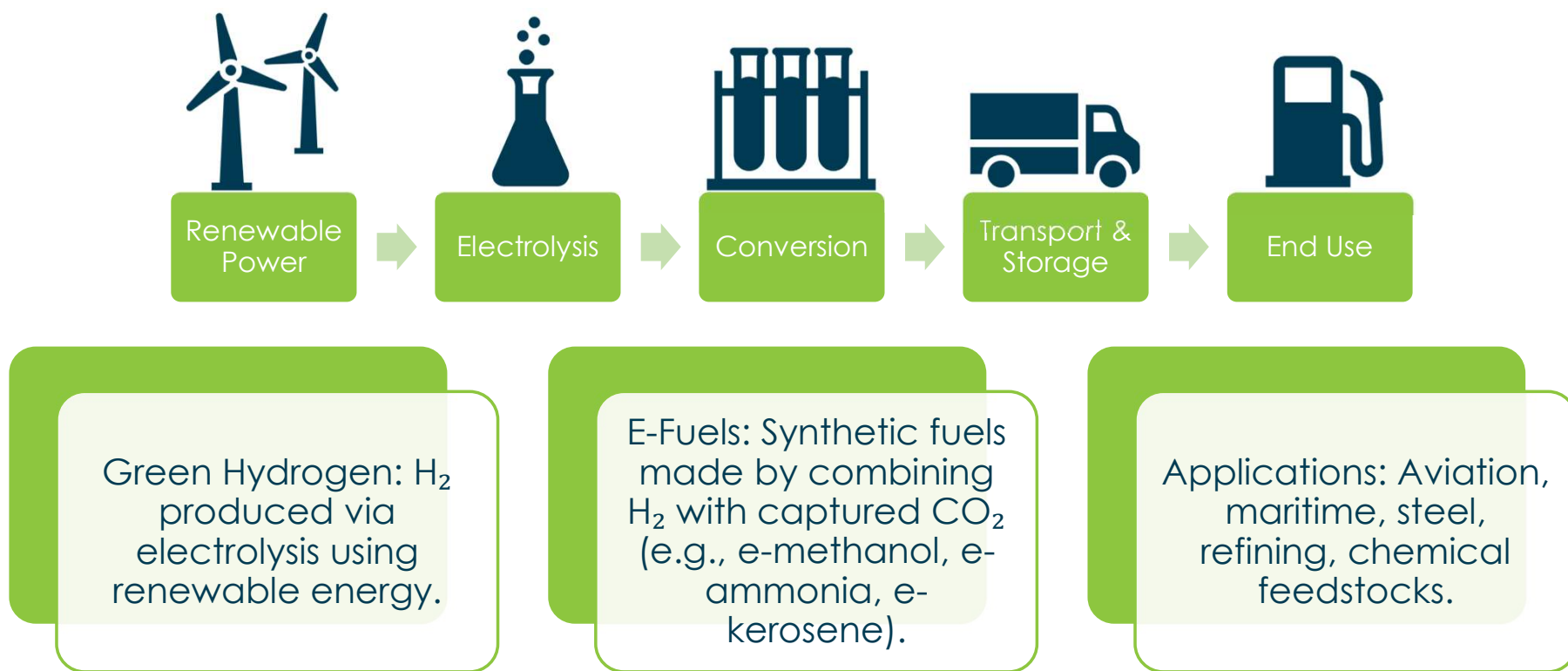


How do CapEx, OpEx, and LCOX compare?

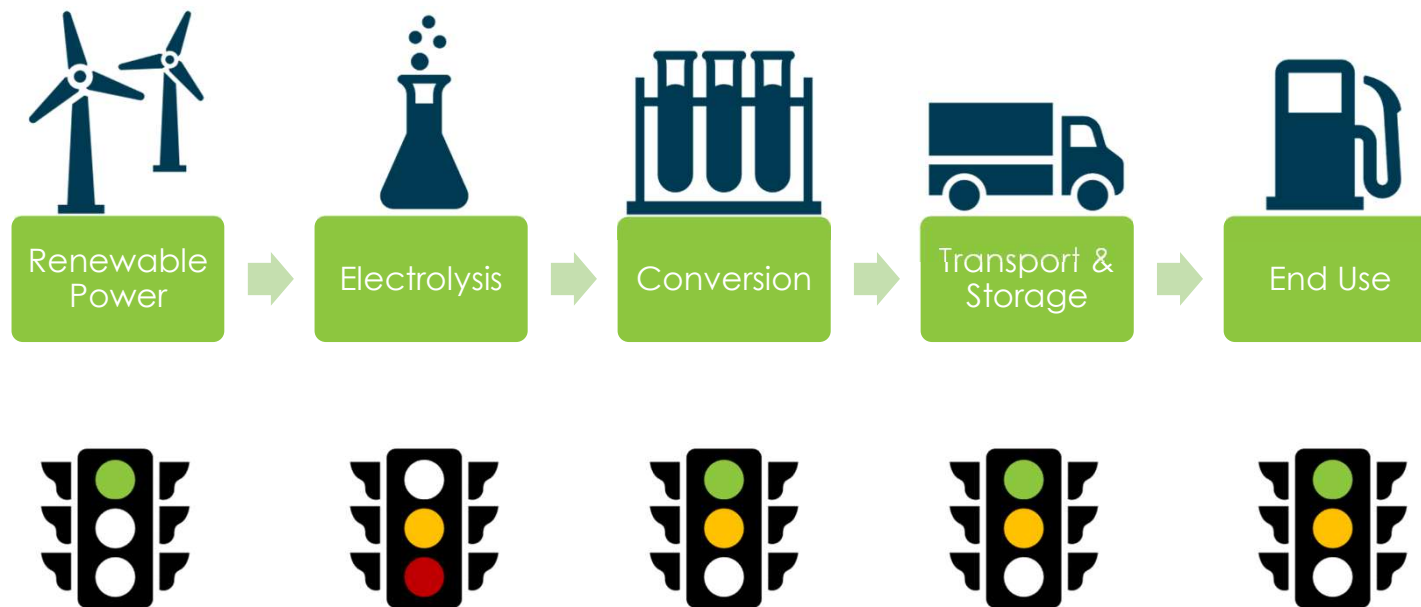


What needs to change to enable commercial scale-up?

# What Are Hydrogen and E-Fuels?

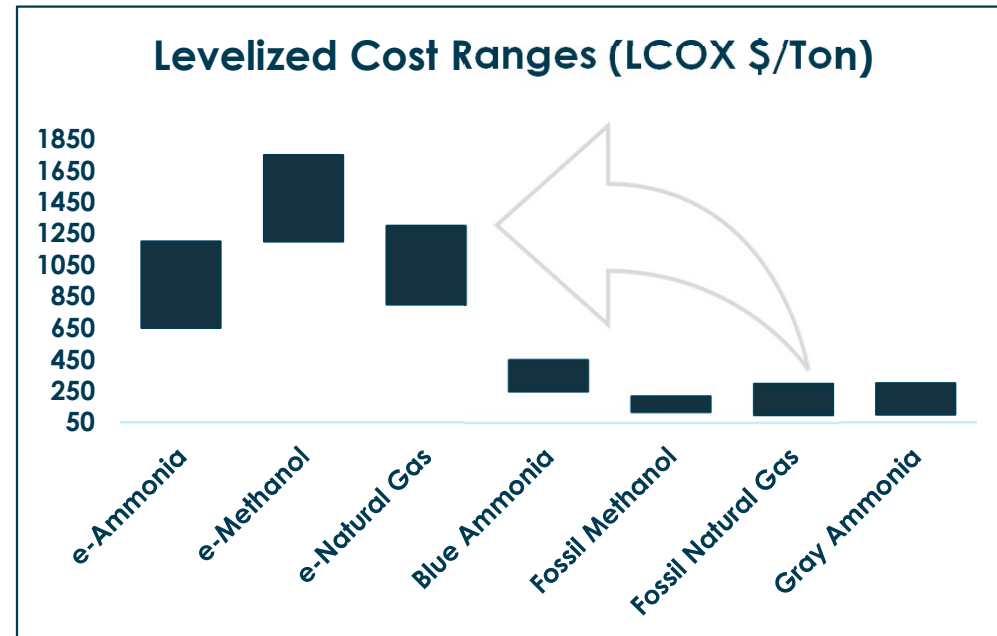
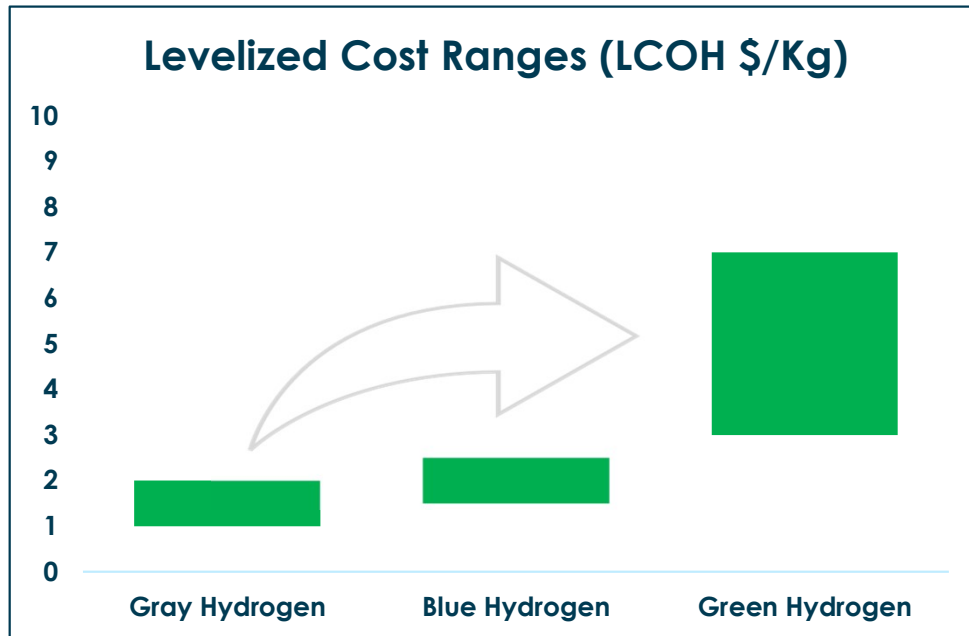


# Technology & Commercial Maturity



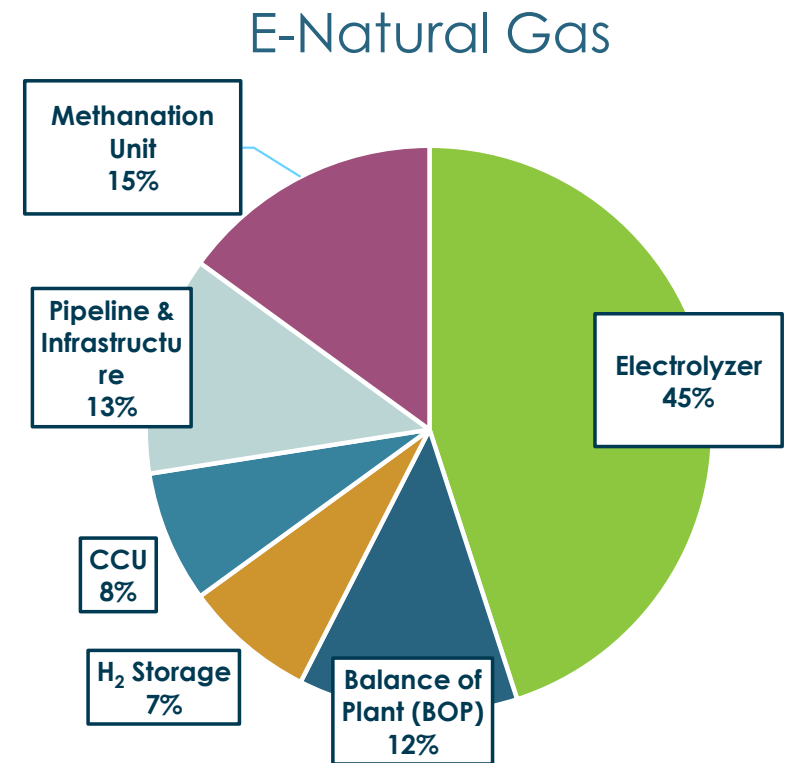
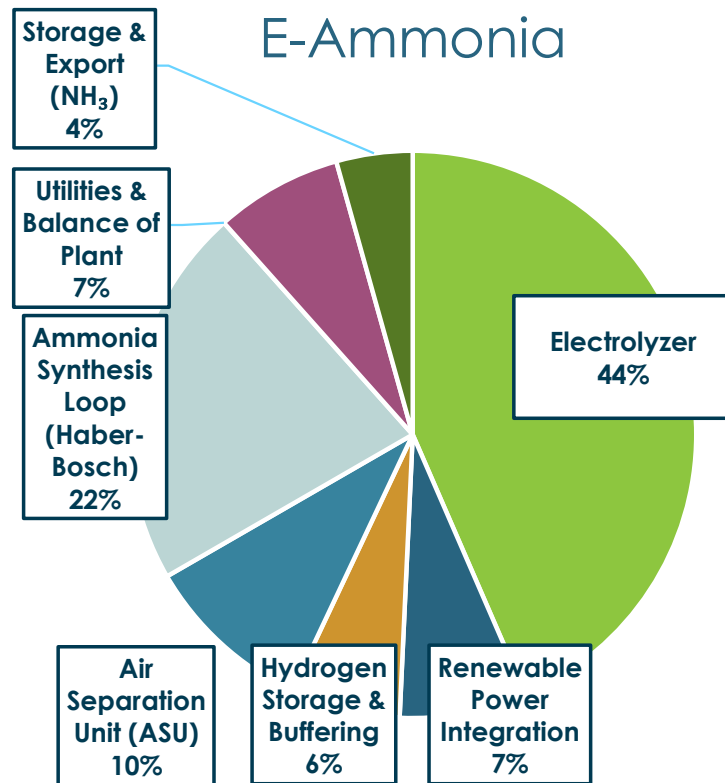


# Levelized Costs: Hydrogen & Fuels

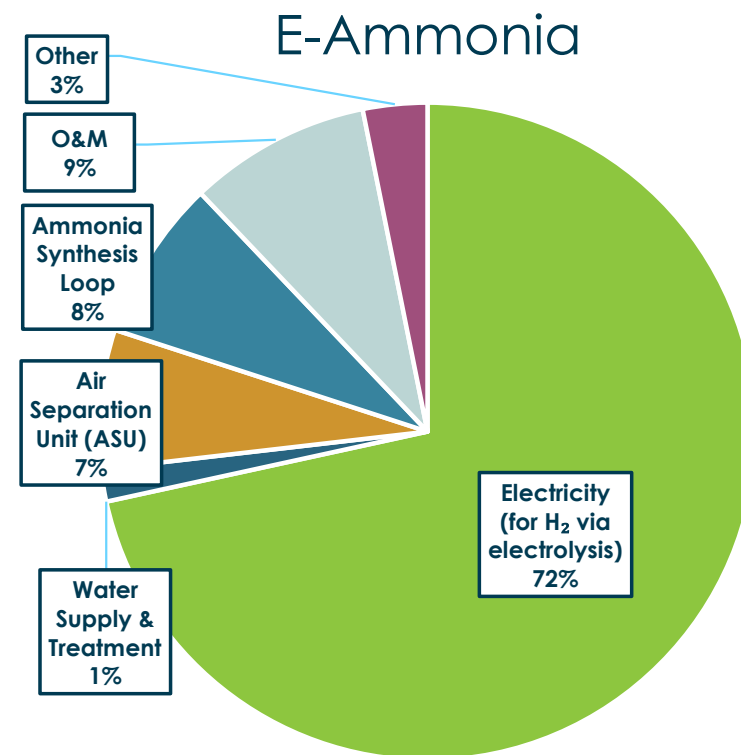
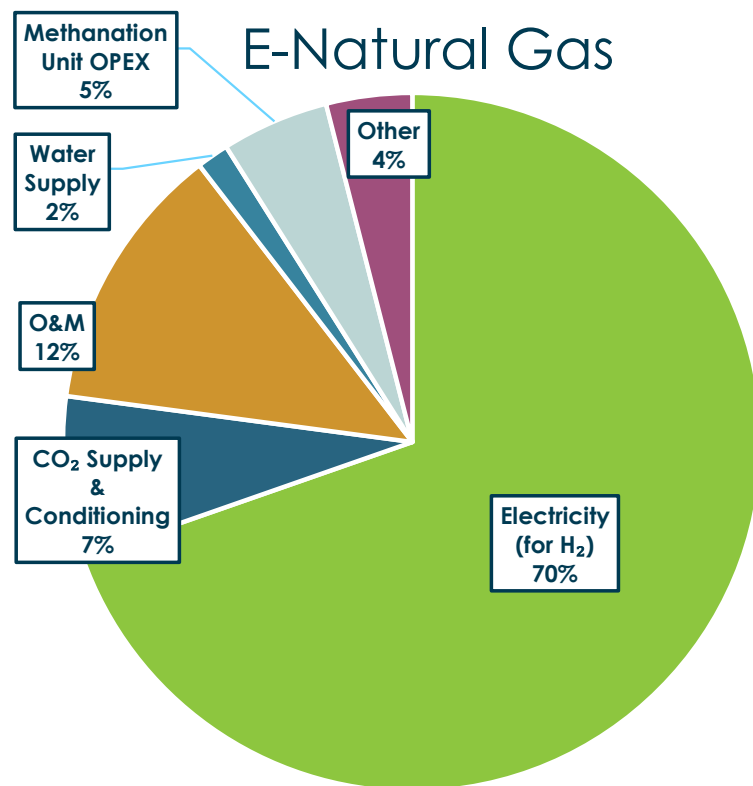


**LCOX** is a metric used to evaluate the **average cost per unit** of a product (e.g., \$/MWh, \$/kg, \$/ton) over the **entire life cycle** of a project or asset,

# CapEx Distribution



# OpEx Distribution





# 6 Key Challenges to Viability

## High Production Costs

- Electricity accounts for 60-75% of OpEx
- Electrolyzer accounts for 40-50% of CapEx
- Conversion plant CapEx leads to high LCOX

## Low Technology Maturity (TRL < 9)

- SOEC electrolysis still in development
- CO2 capture for RFNBO is costly
- E-kerosene, LOHCs are nascent

## Infrastructure Gaps

- Transport and Storage are costly
- Lack of pipelines
- Insufficient ports/export hubs

## Limited Market Demand & Offtake

- Unclear business models
- RFNBO certification barriers

## Policy & Regulatory Misalignment

- Lack of carbon pricing or mandates
- Subsidy gaps

## Project Development & Risk Barriers

- Unproven business cases
- Weak front-end loading

# Key Levers to ensure Techno-economic viability



CAPEX  
REDUCTION –  
ELECTROLYZER,  
BOP,  
CONVERSION



RENEWABLE  
POWER COST,  
UTILIZATION



NOVEL BUSINESS  
MODELS








LARGE SCALE  
PROJECTS AND  
INTEGRATION



INFRASTRUCTURE  
FOR TRANSPORT,  
STORAGE AND  
END USE



# Specific Actions

	Area	Levers
	<b>Technology</b>	Scale-up electrolyzer manufacturing, advance SOEC, improve CO <sub>2</sub> capture integration
	<b>Cost</b>	Lower renewable electricity costs, modular plant design, improve load factors
	<b>Project Delivery</b>	Use Risk management, FEL, Value Engineering, and digitalization for cost certainty and risk reduction
	<b>Policy</b>	Carbon pricing, fuel mandates, global RFNBO alignment (low influence)
	<b>Market</b>	Anchor offtake agreements, hydrogen hubs, guaranteed minimum demand (low influence)

# Conclusion - Low Hanging Fruits

- **Negotiate Renewable PPAs for Electrolyzers**
- **Modularize E-Fuel Plant Designs**
- **Benchmark and Share LCOX Data Transparently**
- **Apply Value Engineering and Front-End Loading (FEL)**
- **Retrofit Existing Infrastructure**



# Conclusion-Stakeholder Actions

- **Accelerate Demonstration Projects**
- **Push for Policy Alignment and Carbon Pricing**
- **Deploy Blended Finance and Risk-Sharing Models**
- **Integrate Projects into Industrial Clusters**
- **Build Capacity and Standardization**





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# Reinforce (outside the slides)

- ⚡ **Electricity is the Dominant Cost Driver**  
Focus on electricity price, load factor, and utilization to control LCOH/LCOX.
- 🧪 **TRL Gaps Exist in Conversion and End Use**  
Investment needed to scale SOEC, methanation, e-kerosene, and downstream technologies.
- 📈 **Techno-Economic Gaps Can Be Bridged**  
With scale, integration, and policy support, e-fuel LCOX can drop by 40–60% in the next 5–7 years.
- 🔄 **Hydrogen Alone is Not the Goal**  
The real value lies in integrating hydrogen with **e-fuel conversion** and **decarbonized molecules**.
- 🤝 **Cross-Sector Collaboration is Non-Negotiable**  
Success depends on alignment between energy producers, OEMs, offtakers, policymakers, and investors.

