

Pathway to a Chicago Hydrogen Hub

Jon Horek

Advanced Energy Group 21Q4 Stakeholder Challenge Dinner

December 8th, 2021



A Historic Moment for Decarbonization



Decarbonization and Resiliency Services

Sargent & Lundy

CO₂ Capture



- S&L is Industry Leader
- FEED and OE for largest CCUS Project
- Active with multiple technologies
- 25+ active projects, ranging across Coal, NGCC, Industrial, Feasibility, Pre-FEED, FEED Studies, Pilot projects



Solar / Wind

- Full-scope engineering / design
- Solar resource assessment
- Array layout / design
- Evaluate fixed tilt v. tracking
- Wind resource assessment / layout



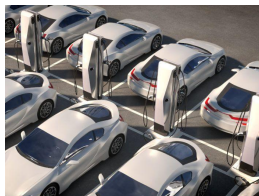
Small Modular Reactors

- Zero-carbon, dispatchable
- NuScale – NRC approval in 2020
- S&L designing nuclear island

Sargent & Lundy

Electric Vehicles

- EV Station Design
- Grid Studies
- Station placement
- Renewable Integration
- BESS Integration



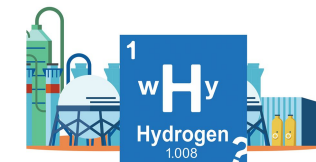
Battery Energy Storage Systems (BESS)



- Interconnect / ISO Modeling
- Proforma Analysis
- Detailed Design
- Design & Integration of 20+ Battery projects (600+ MW / 2400+ MWh)
- OE Development (1000MW+ / 4000+ MWh)

Electric Grid Integration

- Load flow modeling
- Asset dispatch modeling
- Interconnection applications
- Full Integration
 - Renewables
 - Dispatchable Generation
 - Load growth / shift
 - Storage Systems
 - VAR compensation



Hydrogen

- S&L Engineer of Record – H₂ Blending Demo Project for NYPA
- Design studies for H₂ production at nuclear stations, solar fields, and wind farms
- Feasibility and economic study of H₂ production and storage

Answering the Key Questions for EV Clients



Where should charging stations be located?

How will charging impact the grid?

How will stations connect to the grid?

How should we design stations to minimize impact and maximize benefit?

How should fleet transitions be planned?

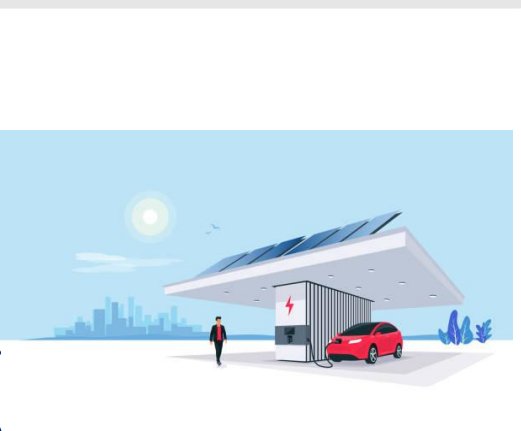
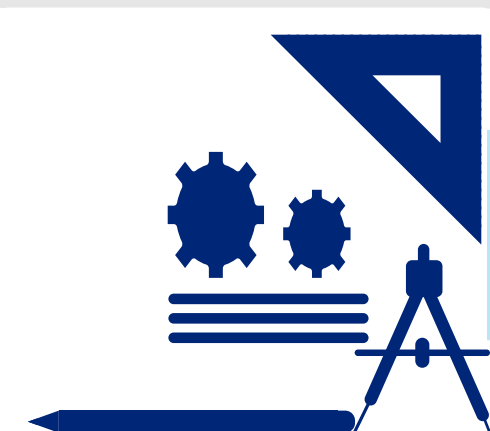
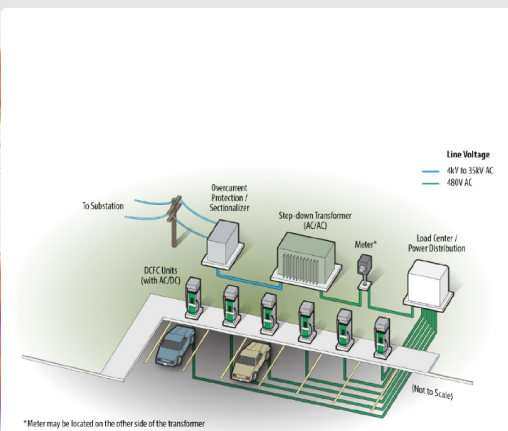
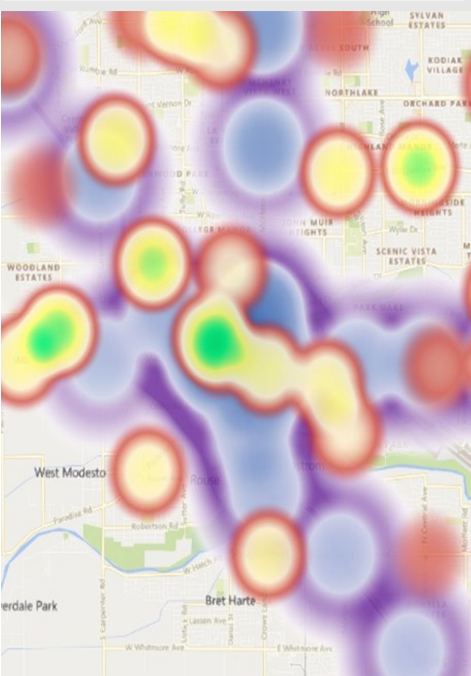
Network Model

Electric System Analysis for EV Penetration

EV Interconnect Standards Development

Innovative Microgrid EV Station Design

Fleet and Logistic Center Strategy and Planning



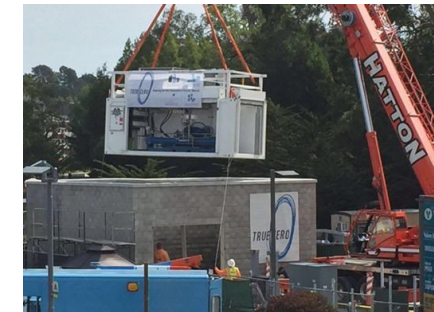
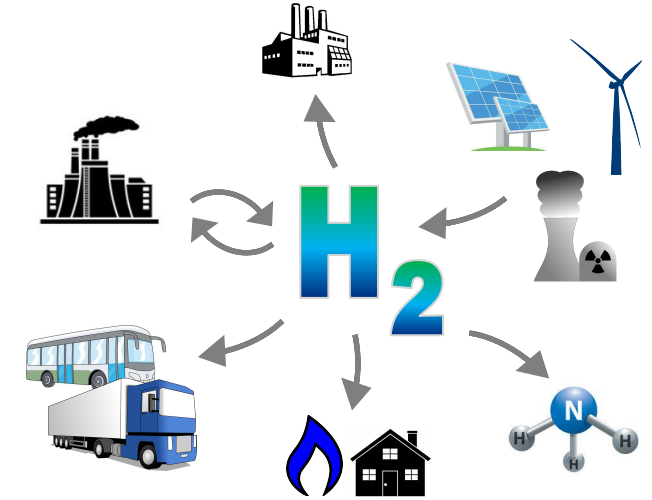
Infrastructure Assessment
 Our team would work with yours to identify infrastructure options to support the technology for zero emission transportation including evaluation of electrical and civil requirements.

Multi Year Plan
 We would design and deliver a multi-year phased plan with assessment points to address the plan and optimize the fleet conversion and deployment.

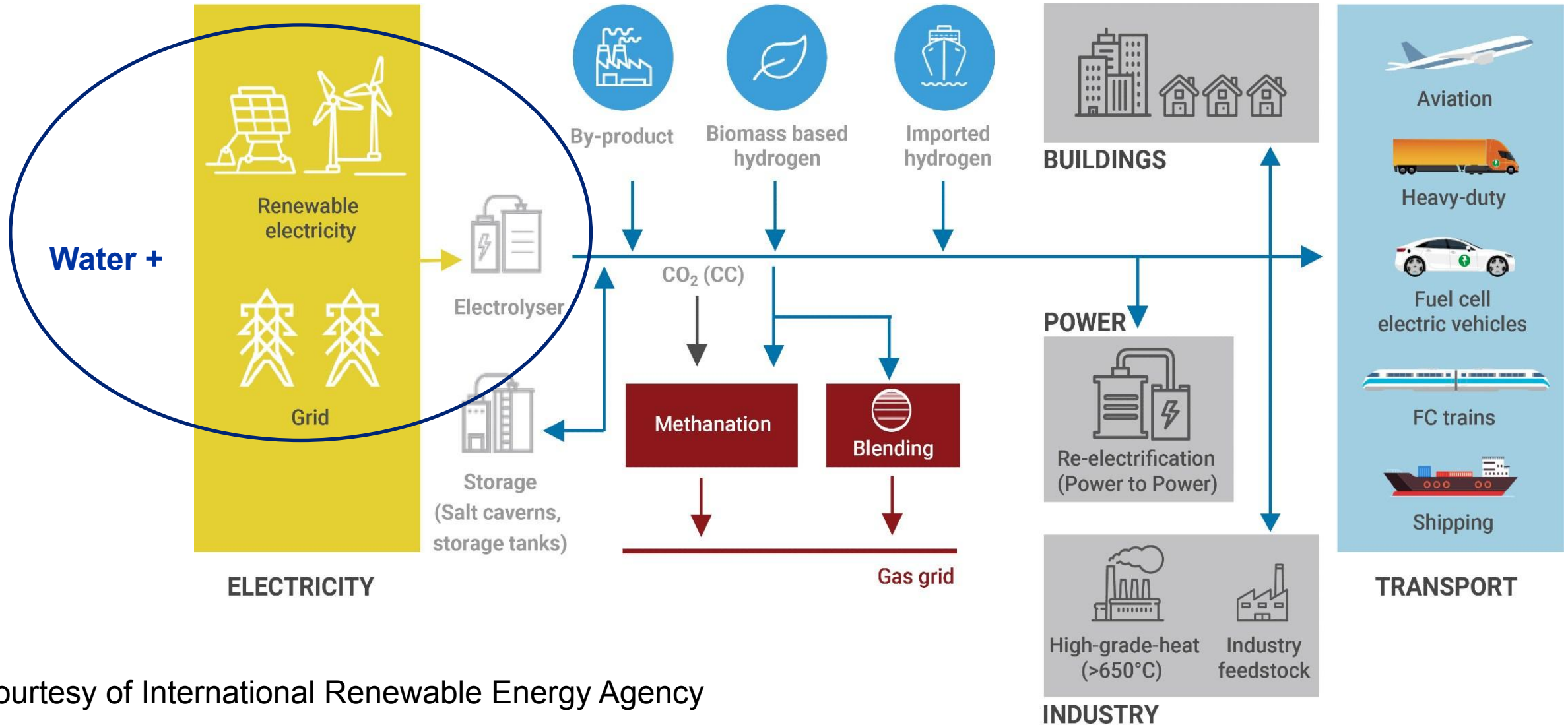
End to End Lifecycle planning
 Our approach would be collaborative with all members of the operating team to ensure every part of the operation is covered with a solution and plan.

S&L Hydrogen Market Activities

- 20 active and completed Owner's Engineering projects
 - Production evaluations for cold and hot electrolysis
 - H₂ production, compression, and storage studies
 - H₂ blending and coal conversion feasibility studies (CTs, boilers)
 - Financial modeling assessments
 - Demonstration testing reviews
- Diverse client base
 - Utilities and Independent Power Producers: fossil, nuclear, and renewables
 - Electric Power Research Institute, DOE, and National Research Labs
 - OEMs: H₂ suppliers, Electrolyzer vendors
- Participation in H₂ industry forums
 - Committees (CIGRE, CATF Nuclear Hydrogen Initiative, California Hydrogen Business Council)
 - Conferences and virtual roundtables



Hydrogen as Versatile Energy Carrier



Courtesy of International Renewable Energy Agency

Federal Hydrogen Funding

Hydrogen in the Infrastructure Bill signed 11/15

- \$8B allocated for at least four hydrogen hubs
- \$500M for manufacturing and recycling of fuel cells
- \$1B for clean hydrogen production (clean defined as $< 2 \text{ kg CO}_2$ per kg H_2 produced)
- \$2.5B for clean school buses, \$2.5B for clean ferries
- \$7.5B for fueling and charging infrastructure
- \$2.5B for hydrogen corridors under the FAST Act
- Development of a national clean hydrogen roadmap

Bipartisan H2 Infrastructure Initiative proposed 10/28/21

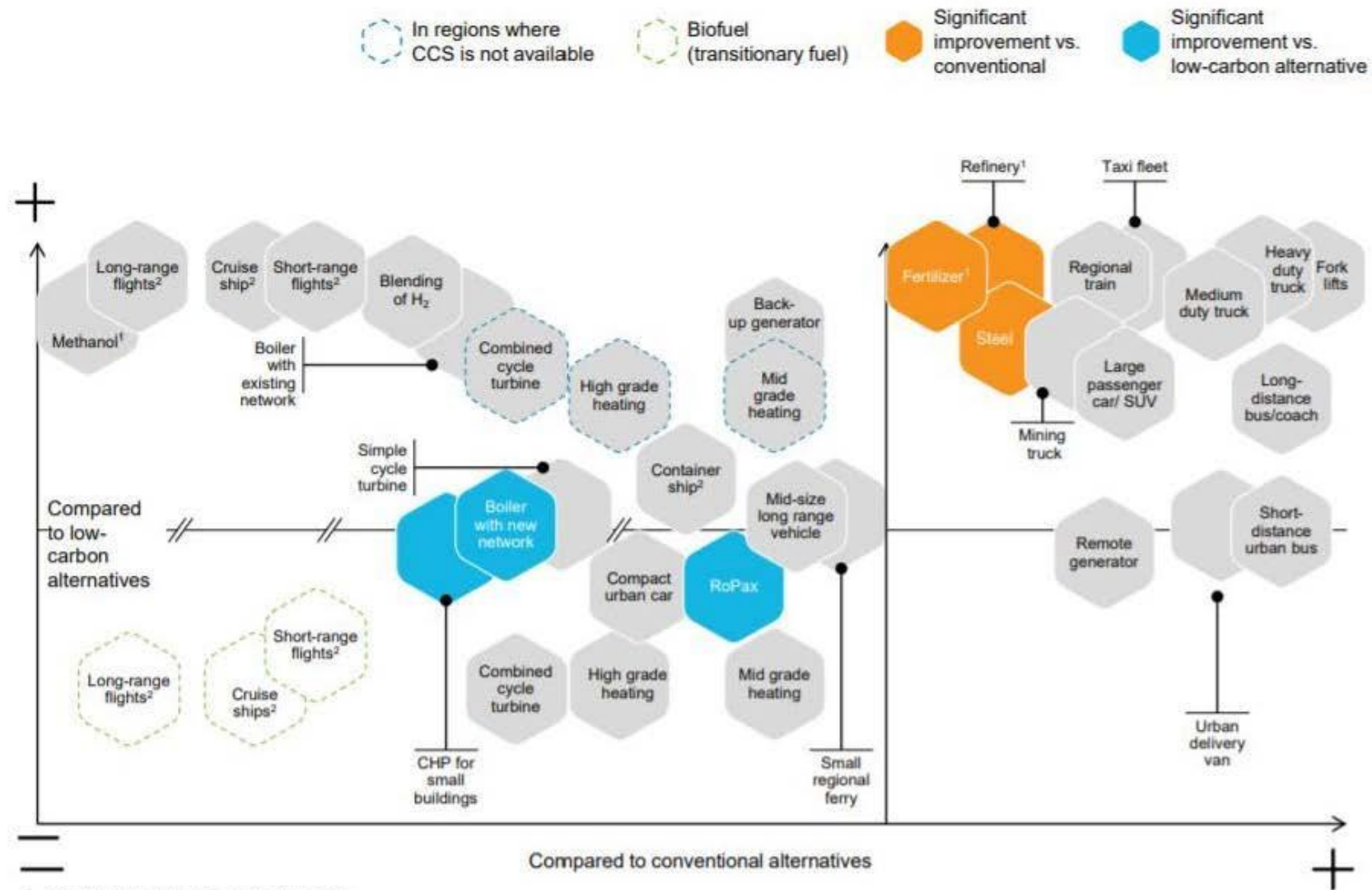
- Three grant and low-cost loan pathways
- Ports/shipping projects; Heavy industry demonstrations; H2 transport/storage/fueling

Proposed “Build Back Better” Bill

- \$3/kg PTC
- 30% ITC

Exhibit 17: Hydrogen competitiveness per end application in 2030

Cost Parity



Hydrogen cost today

- \$5-15/kg (blue /green)
- \$2/kg from NatGas

2030 goal / forecast

- DOE H2 Earthshot: \$1 / 1 kg / 1 decade
- McKinsey forecasts \$1.40-2.30/kg by 2030

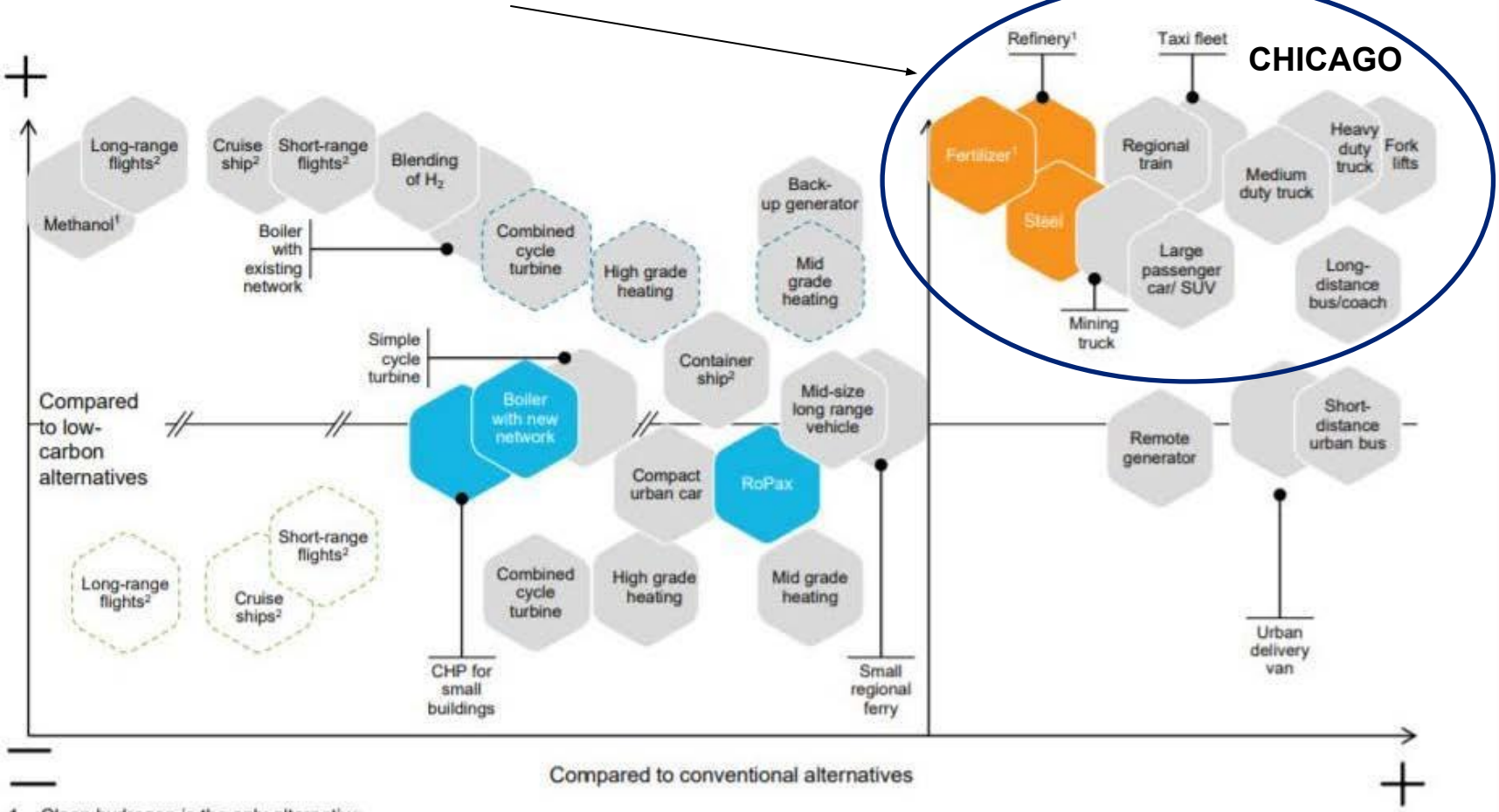
1. Clean hydrogen is the only alternative
2. Carbon breakeven cost represents average cost over lifetime of asset
3. Biofuel is a complementary solution to hydrogen/ syngas particularly used in heavy to decarbonize sectors such as shipping and aviation; usage will be subject to supply constraints

Exhibit 17: Hydrogen competitiveness per end application in 2030

Cost Parity

 In regions where CCS is not available
 Biofuel (transitional fuel)
 Significant improvement vs. conventional
 Significant improvement vs. low-carbon alternative

CHEAPER THAN CONVENTIONAL AND LOW CARBON ALTERNATIVES



Hydrogen cost today

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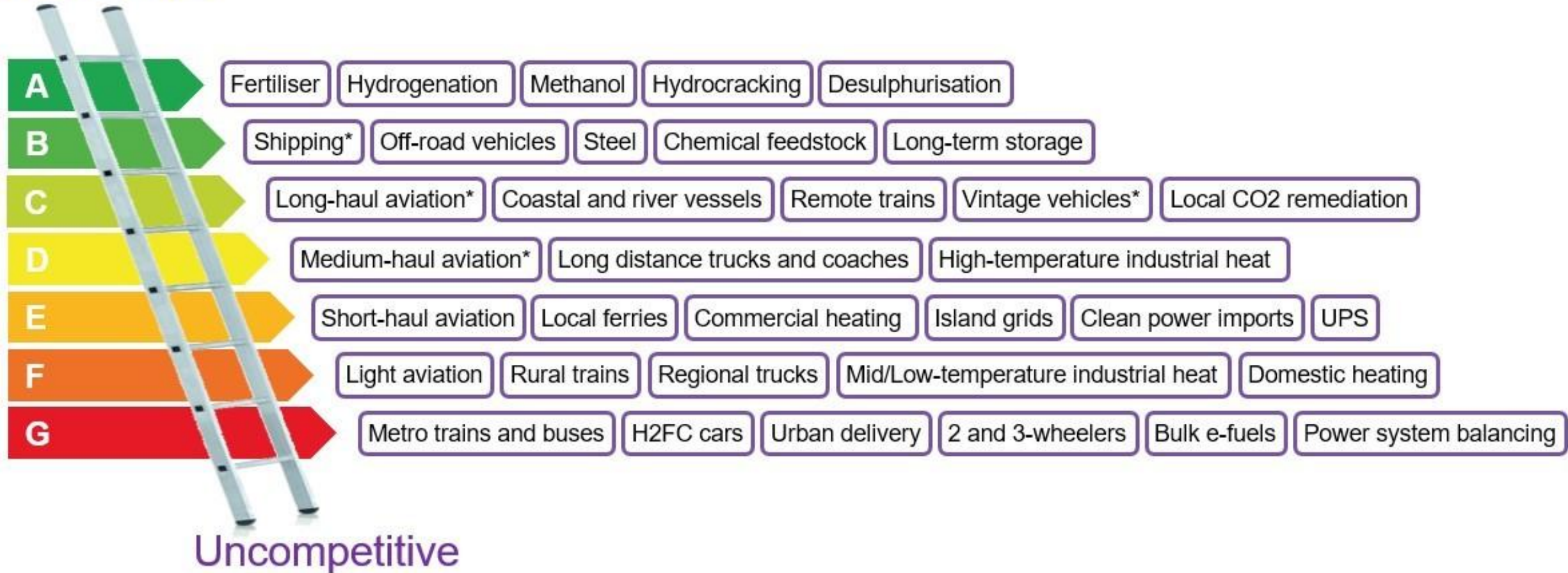
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Alternate Review of Hydrogen Applications

Unavoidable



* Via ammonia or e-fuel rather than H2 gas or liquid

Source: Liebreich Associates (concept credit: Adrian Hiel/Energy Cities)

Emergence of Hydrogen Hubs

Australia
Germany
United Kingdom
Japan
United States
Norway
South Korea
New Zealand
Denmark
EU Hydrogen
Council
Portugal
International
Energy Agency
China
North Africa
Canada



- Local hubs to implement national roadmaps
- Chicken/egg problem – coordinated markets
- Reduced shipping costs

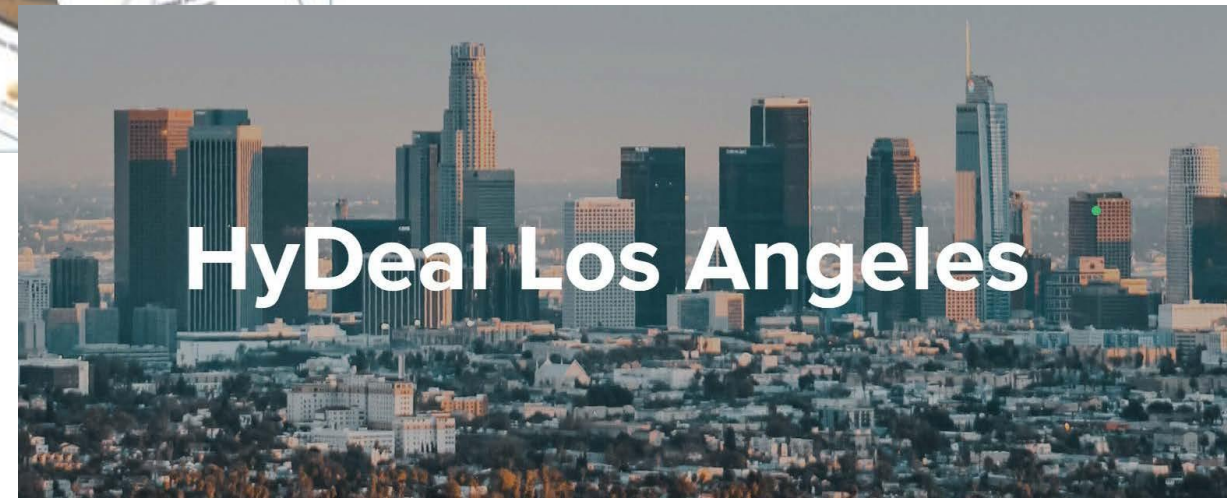


Emergence of Hydrogen Hubs

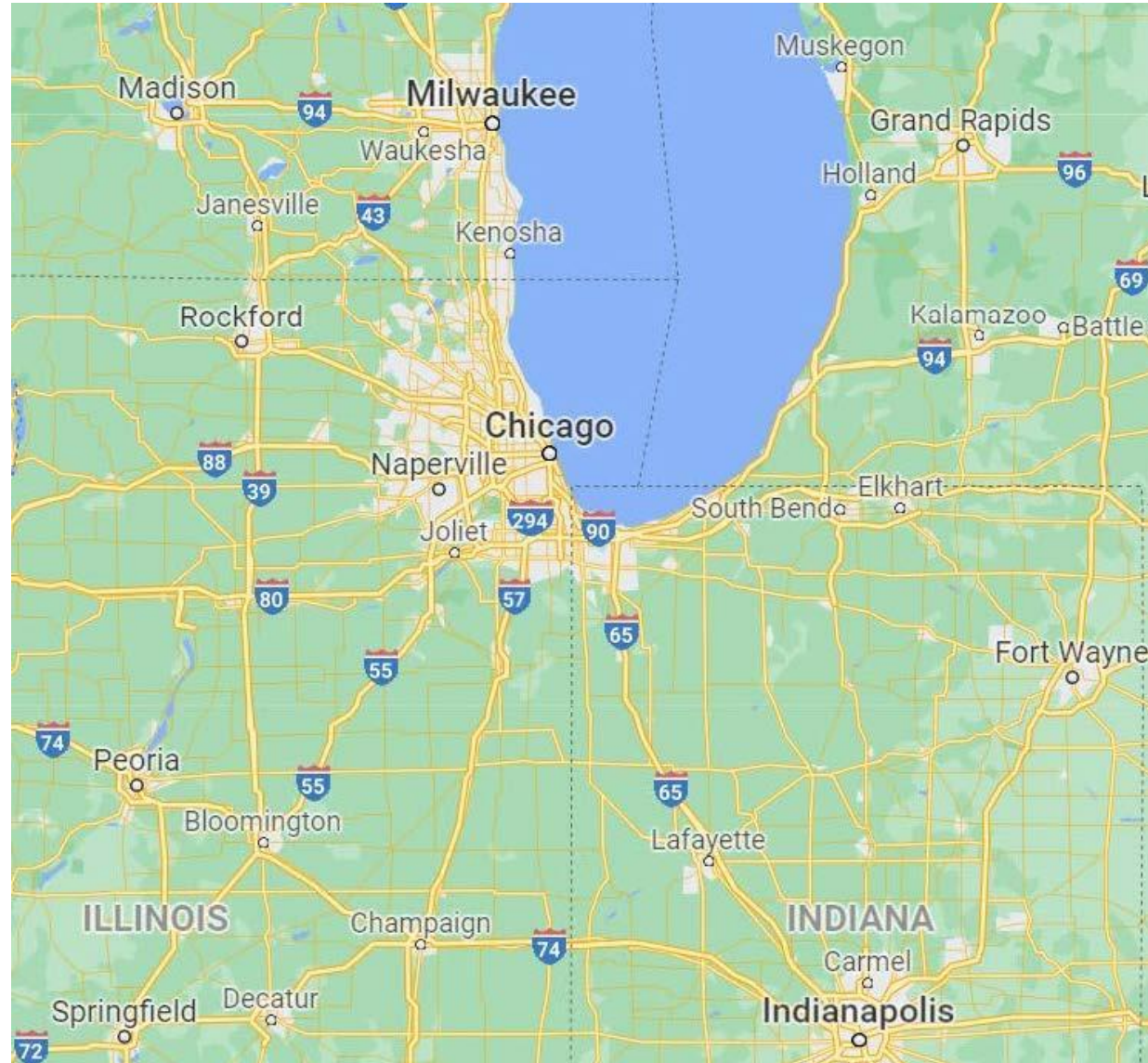
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Norway
South Korea
New Zealand
Denmark
EU Hydrogen
Council
Portugal
International
Energy Agency
China
North Africa
Canada



- Local hubs to implement national roadmaps
- Chicken/egg problem – coordinated markets
- Reduced shipping costs



Pathway to a Chicago Hub



Nuclear power
1st in nation
(GW installed, EIA)

Wind power
5th in nation
(GW installed, EIA)

Great Lakes water
2nd largest globally
(by volume)

CO₂ sequestration
Illinois Basin downstate

U/G salt formations
Much of Michigan

A pipeline crossroads

Steel production
NW Indiana 1st in nation

Oil refining
6th largest in nation
(BP Whiting, EIA)

Ammonia production
Present downstate

Global logistics hub
Major multimodal port

Pathway to a Chicago Hub



A Complete Local H₂ Supply Chain

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1st in nation
(GW installed, EIA)

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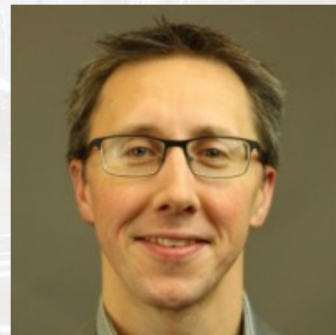
An Obstacle to Overcome



AEG CHICAGO 21Q4 OBSTACLE

REGARDING MOBILITY & TRANSPORTATION, TO ACHIEVE CHICAGO'S CARBON & EQUITY GOALS, A CRITICAL OBSTACLE TO OVERCOME IS ...

The high cost and low supply of decarbonized hydrogen, which could serve as the key decarbonized fuel throughout the heavy transportation and logistics sectors of Chicago.



- JON HOREK
PROJECT MANAGER

Sargent & Lundy

AEG H₂ Hub Proposed 12 Month Solution



AEG CHICAGO 21Q4
STAKEHOLDER DINNER TASK FORCE CHALLENGE

PROPOSED 12 MONTH SOLUTION:
Publish Chicago H2 hub roadmap to share with state and local lawmakers

M1: Publish task force white paper of current publicly known regional hydrogen activities.

M2: Publish task force white paper benchmarking regional activity and policy vs. other emerging global H2 hubs.

M3: Host virtual Chicago H2 hub coordination panel discussion.

The slide features a background image of industrial steel beams. At the top, there is a white banner with the AEG CHICAGO logo. Below this is a dark blue banner with the event title. The main content is on a semi-transparent dark blue background.

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