Pathway to a Chicago Hydrogen Hub

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Advanced Energy Group 21Q4 Stakeholder Challenge Dinner

December 8th, 2021

A Historic Moment for Decarbonization

COP26

AEG

Clean Energy Jobs Act

Repowering Illinois For All

CITY OF CHICAGO
CLIMATE BOND INVESTMENT

CHICAGO'S DOWN PAYMENT ON
CLIMATE RESILIENCY AND MITIGATION

Decarbonization and Resiliency Services

Sargent & Lundy

CO_2 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

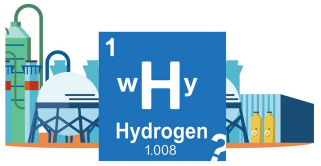
- EV Station Design
- Grid Studies
- Station placement
- Renewable Integration
- BESS Integration

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



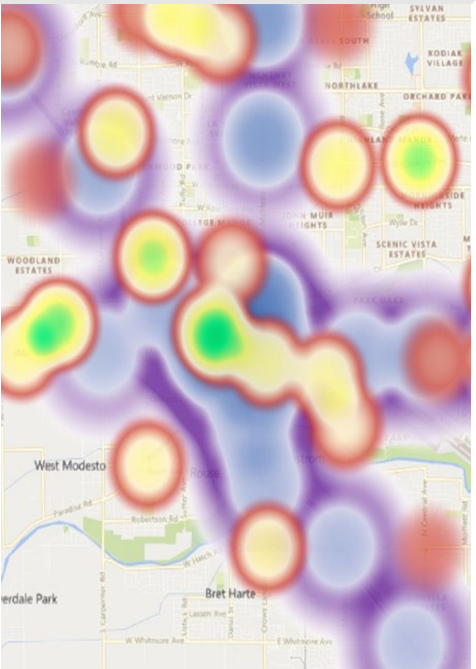
Hydrogen

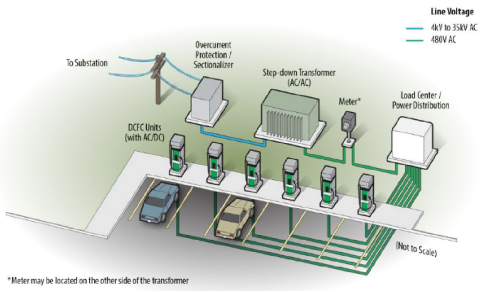
- S&L Engineer of Record – H2 Blending Demo Project for NYPA
- Design studies for H2 production at nuclear stations, solar fields, and wind farms
- Feasibility and economic study of H2 production and storage

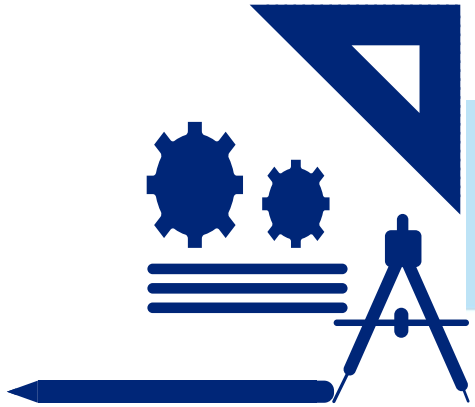
Answering the Key Questions for EV Clients

Sargent & Lundy

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

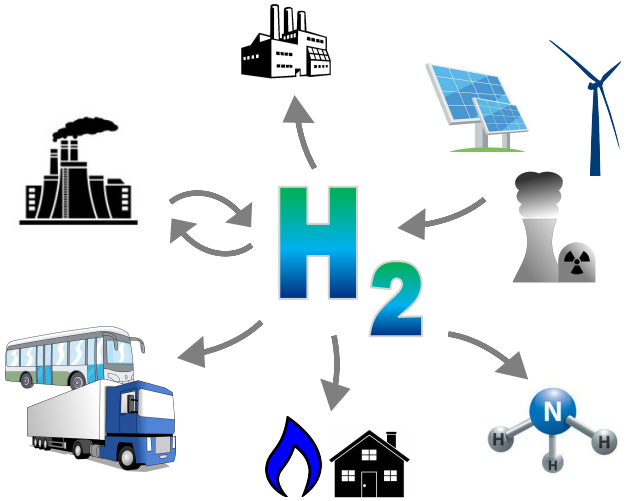
We would design and deliver a multi-year phased plan with assessment points to address the plan and optimize the fleet conversion and deployment.

End to End Lifecycle planning

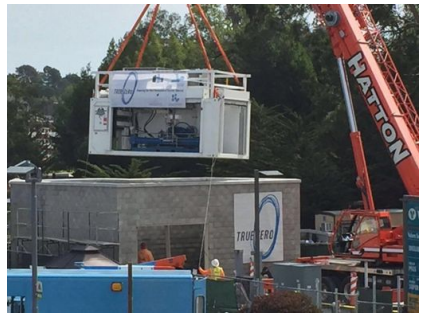
Our approach would be collaborative with all members of the operating team to ensure every part of the operation is covered with a solution and plan.

S&L Hydrogen Market Activities

- 20 active and completed Owner's Engineering projects
  - Production evaluations for cold and hot electrolysis
  - H_2 production, compression, and storage studies
  - H_2 blending and coal conversion feasibility studies (CTs, boilers)
  - Financial modeling assessments
  - Demonstration testing reviews

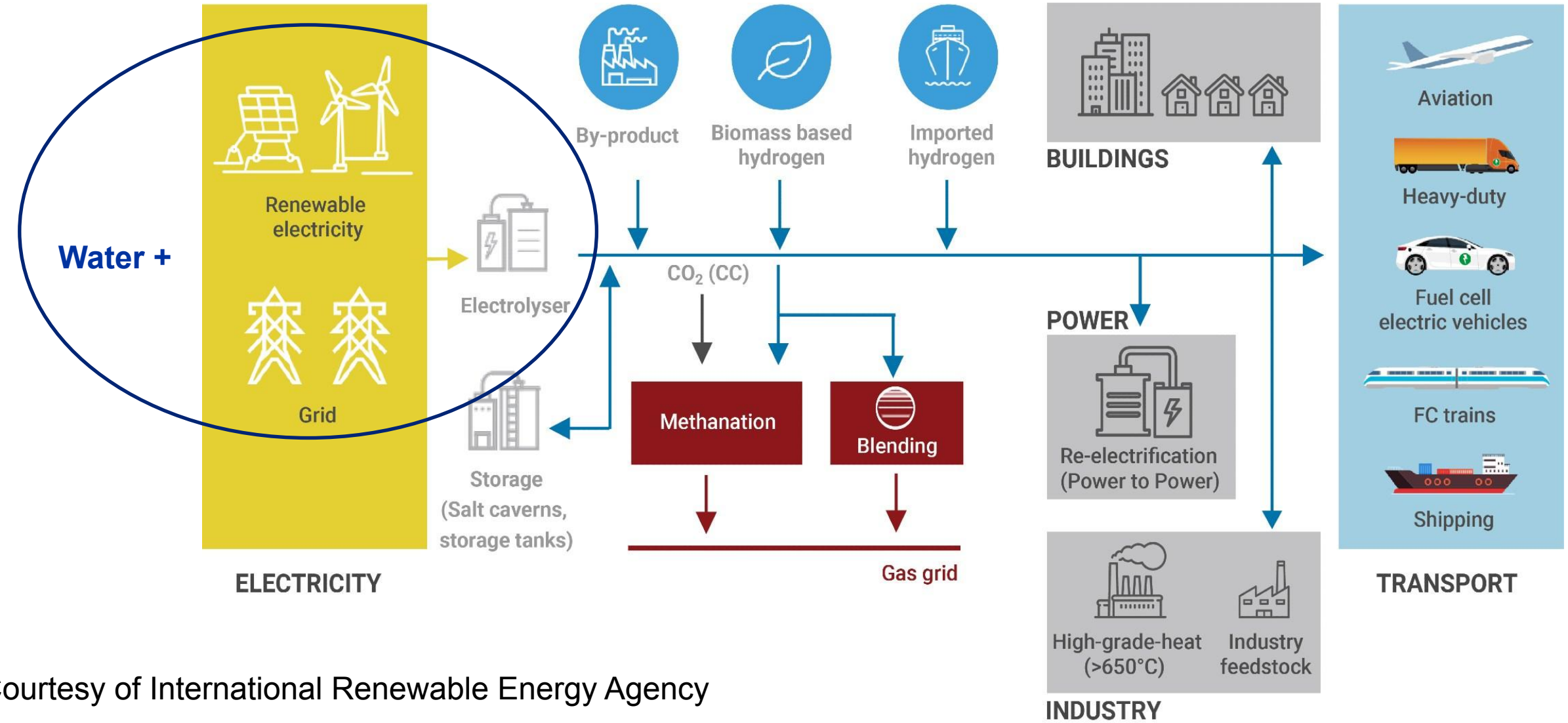


- Diverse client base
  - Utilities and Independent Power Producers: fossil, nuclear, and renewables
  - Electric Power Research Institute, DOE, and National Research Labs
  - OEMs: H_2 suppliers, Electrolyzer vendors



- Participation in H_2 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 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

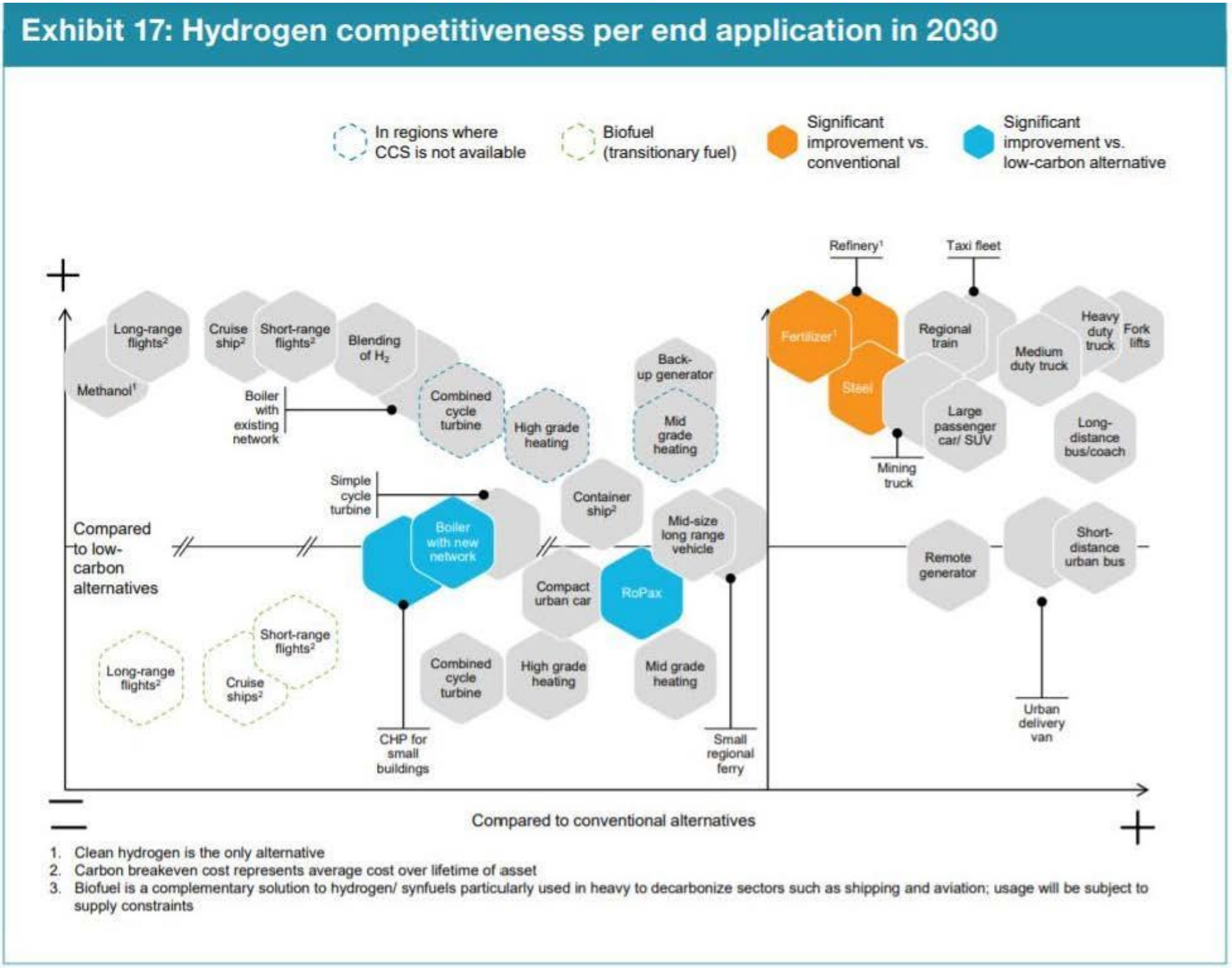
Bipartisan H2 Infrastructure Initiative proposed 10/28/21

- 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

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

Source: McKinsey/Hydrogen Council

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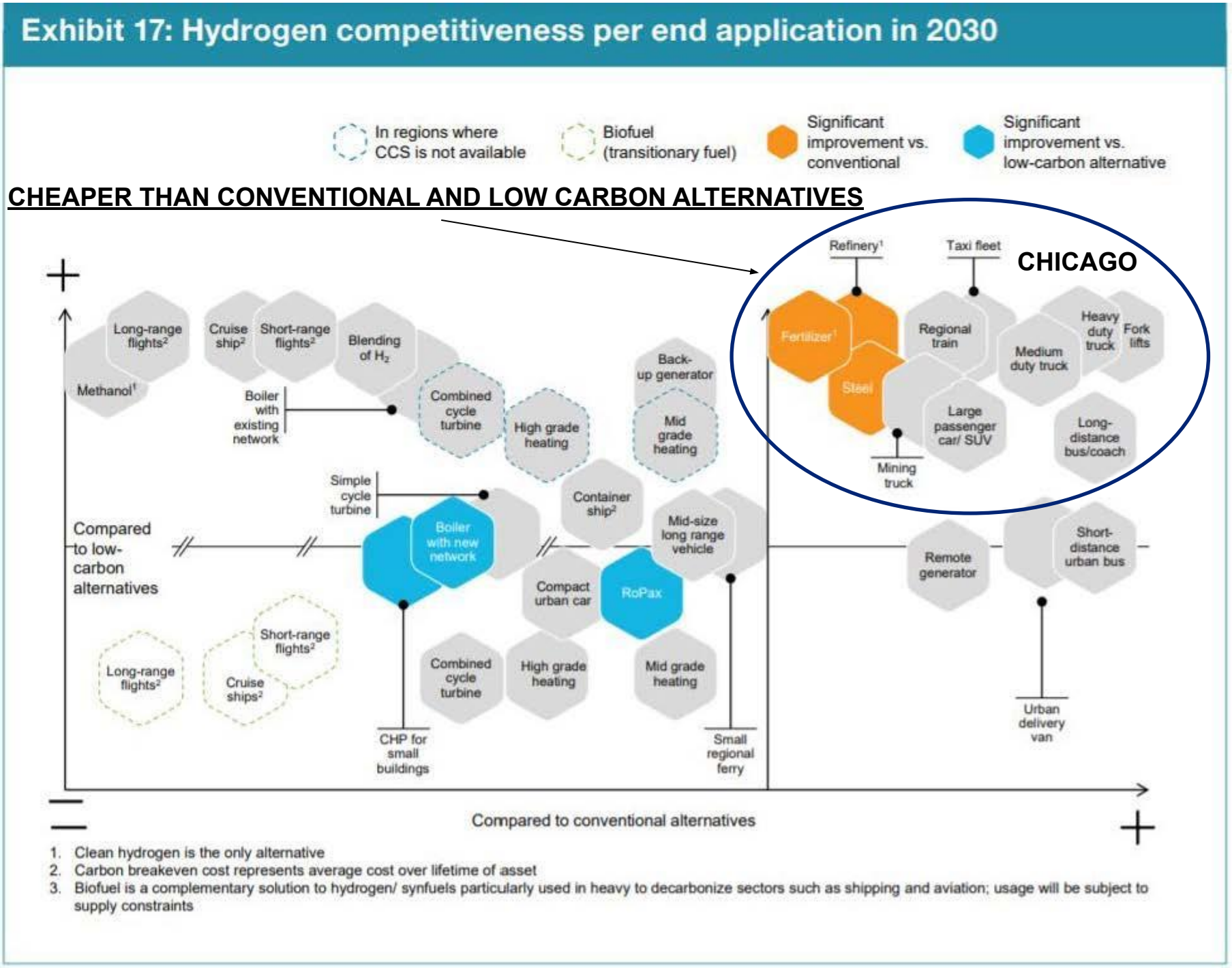

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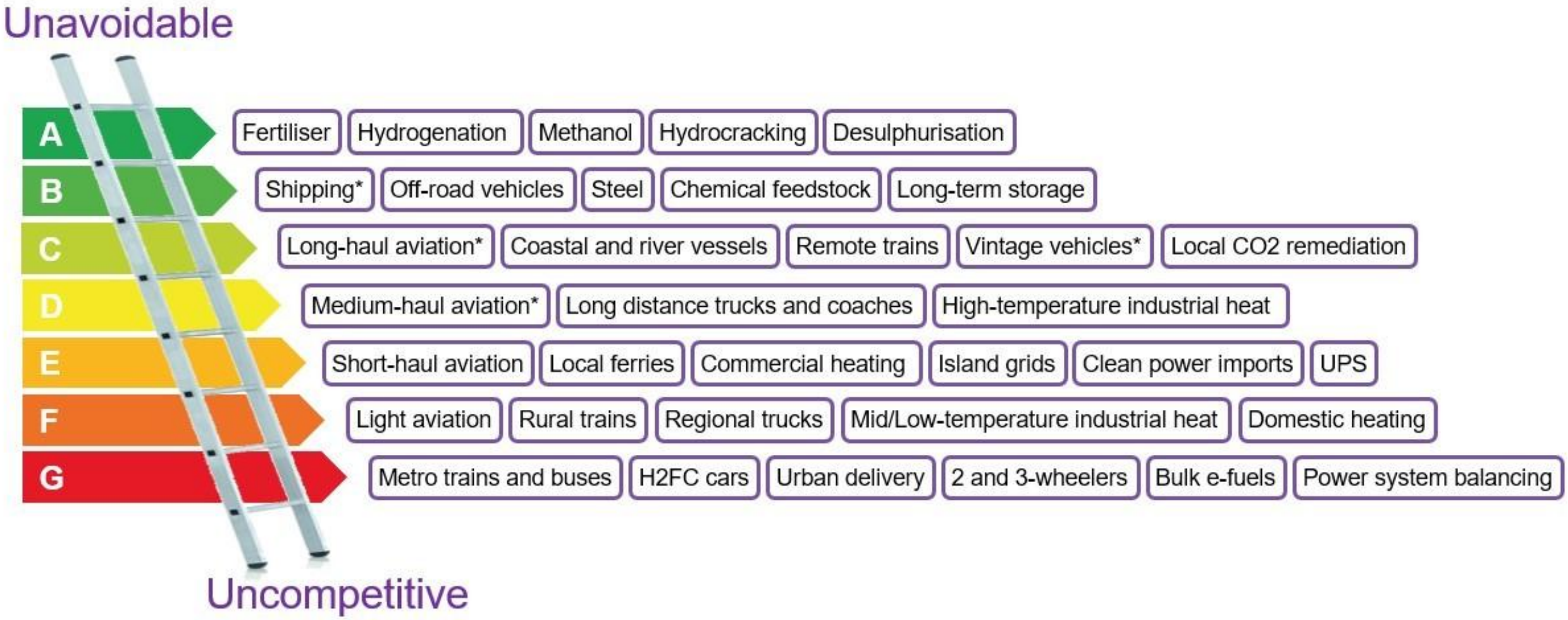
Alternate Review of Hydrogen Applications



** 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

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Pathway to a Chicago Hub

AEG CHICAGO

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

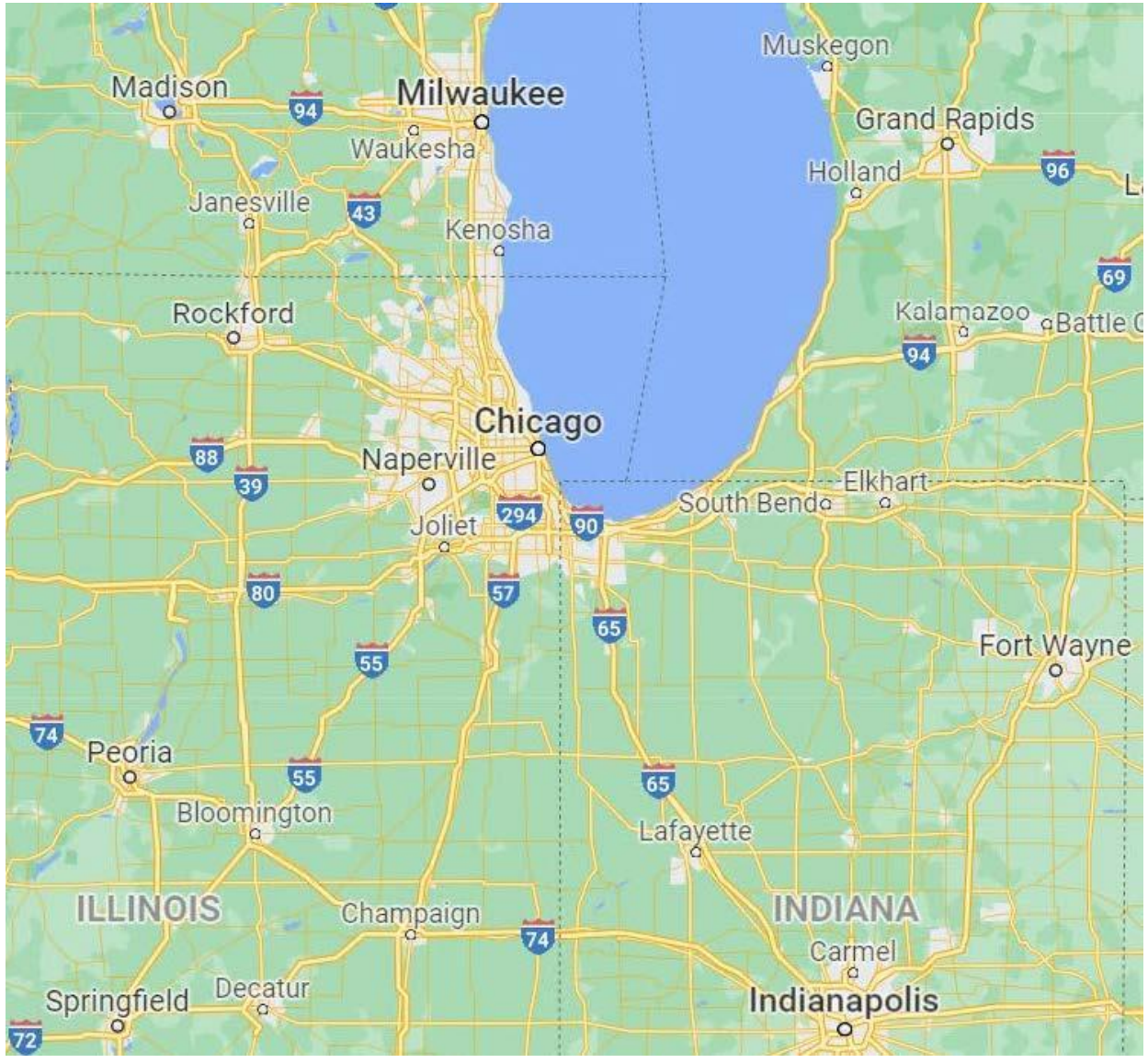
Wind power
5th in nation
(GW installed, EIA)

Great Lakes water
2nd largest globally
(by volume)

CO_2 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

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An Obstacle to Overcome

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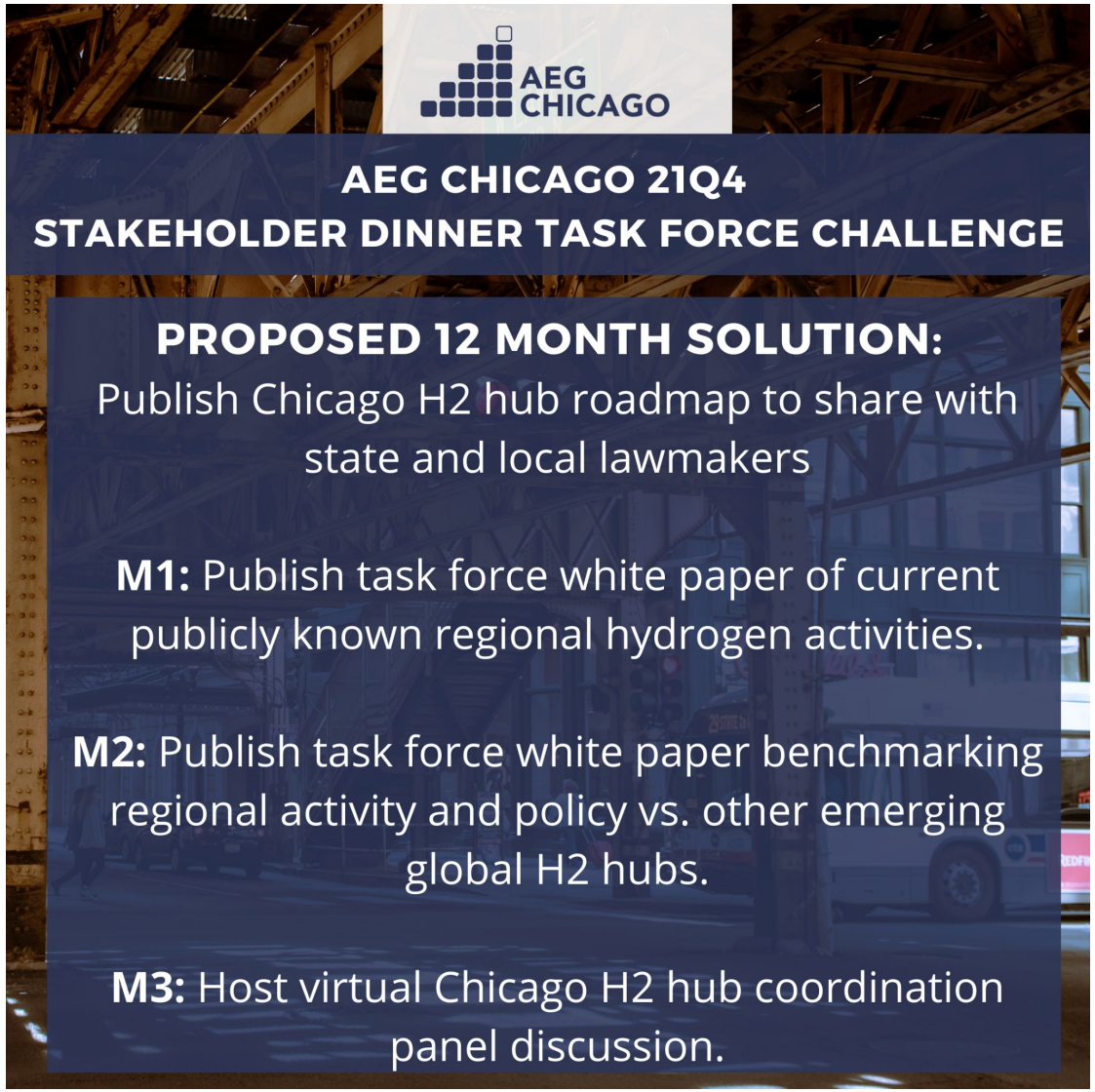
AEG H_2 Hub Proposed 12 Month Solution



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