



H₂ Energy At the heart of the energy transition

Dave Edwards

Director and Advocate for Hydrogen Energy

Air Liquide



**The world leader in gases,
technologies and services
for Industry and Health.**



**Present in
80 countries.**



**Approximately
65,000 employees.**



**More than 3.5 million
customers and patients.**



**292 millions euros of
innovation expenses,**
almost 60% of these expenses
are related to the improving
of the environmental footprint,
air quality and healthcare.



**Around 300 patents
per year.**



**2017 Revenue:
€20.3 billion.
2017 Net profit:
€2.2 billion.**

Air Liquide - Hydrogen Energy



**100 hydrogen stations
designed and installed
in the world.**



**A hydrogen station can
recharge vehicles in
less than 5 minutes.**



**A hydrogen car can ride
more than 600 km with
one charging.**



**Zero CO₂ emission.
Zero particle.
Zero noise pollution.**

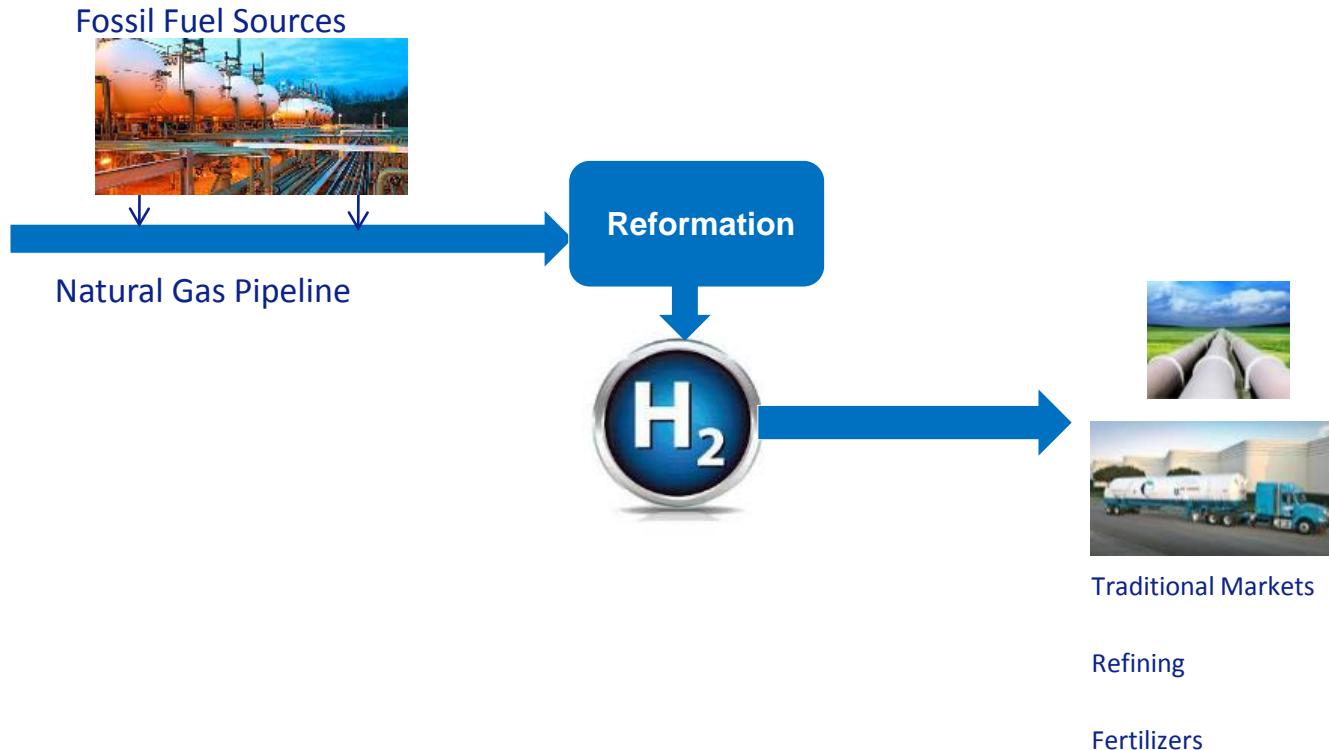


**Hydrogen produced by Air Liquide
in 2016 for the refinery and
petrochemical markets:
14 billion m³.
The current production could allow
to recharge around 10 million
hydrogen Fuel Cell Electric Vehicles.**

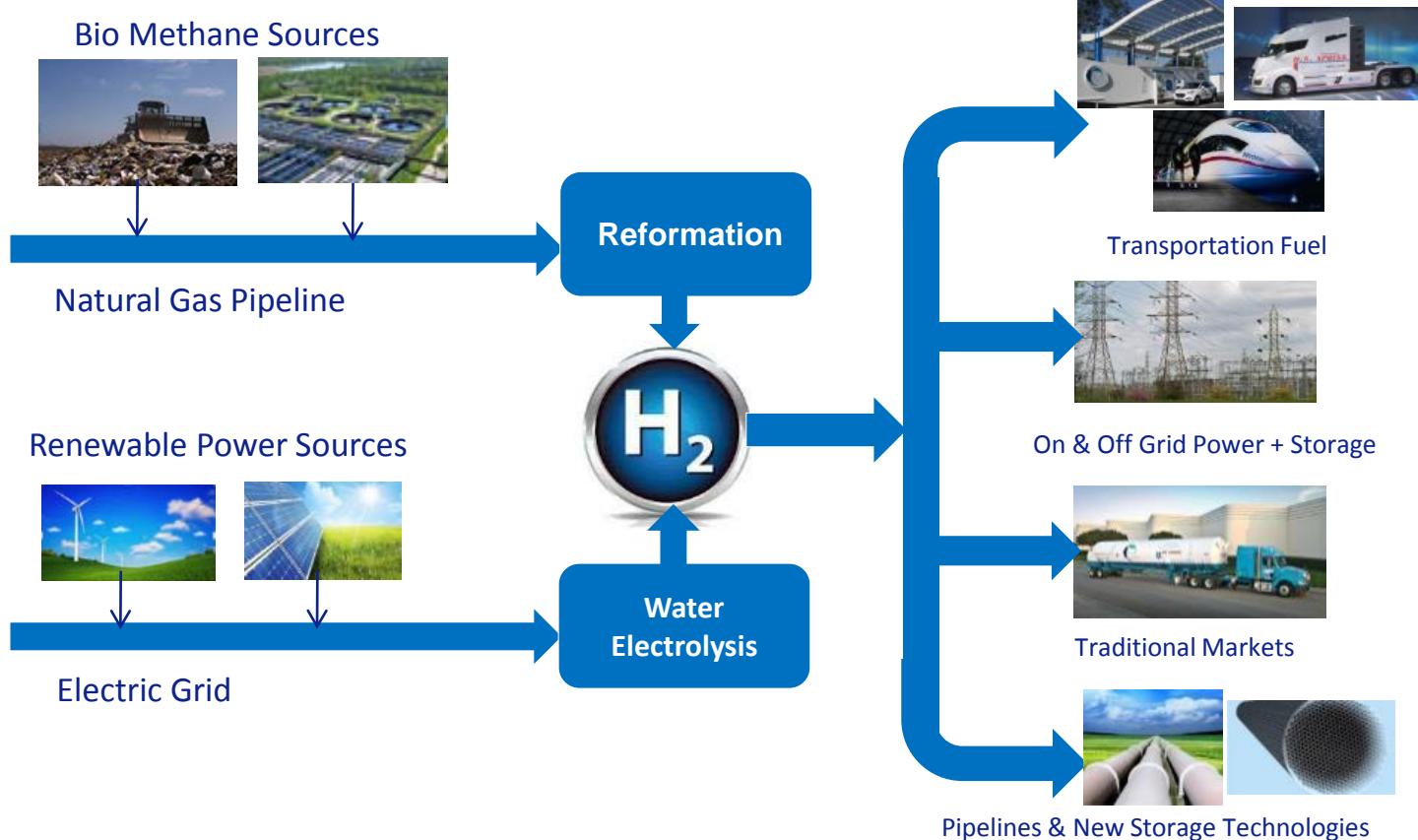


**Revenue from hydrogen
for refineries and
petrochemical markets
in 2016:
€2 billion.**

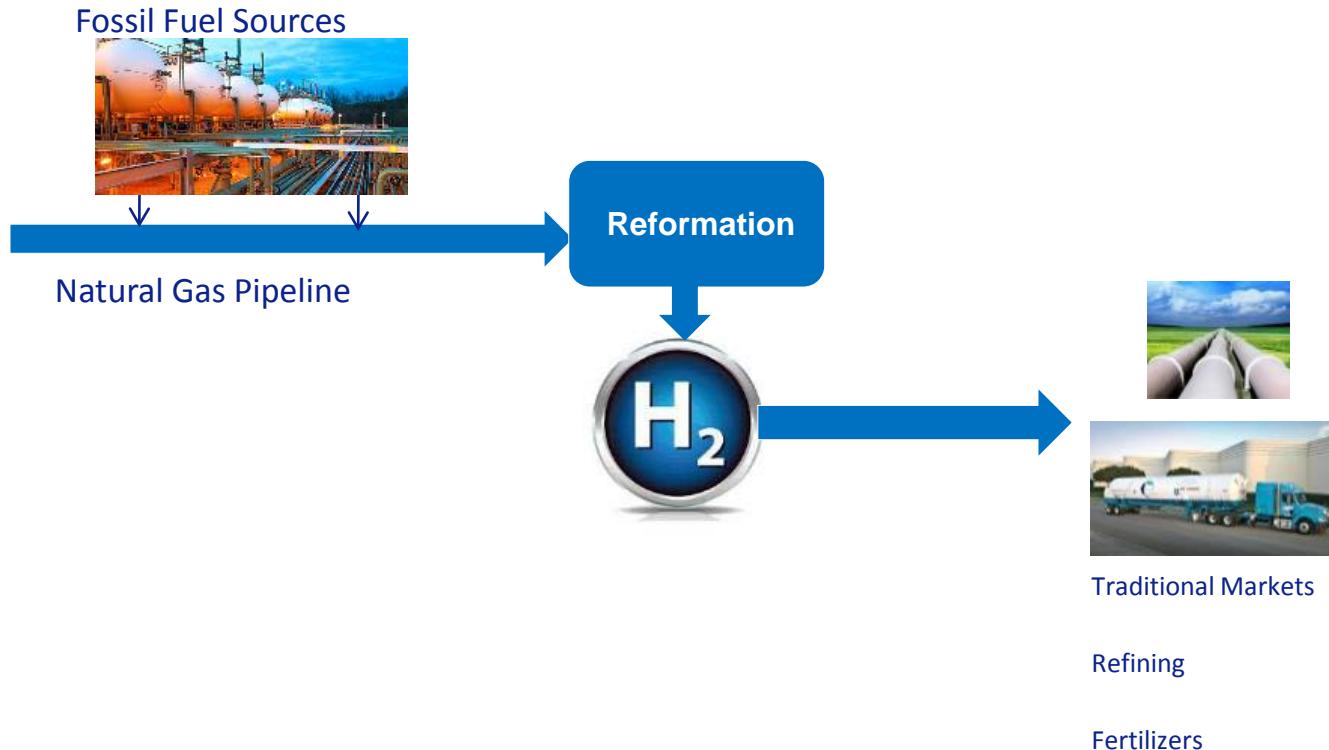
Hydrogen – today's industrial pathway



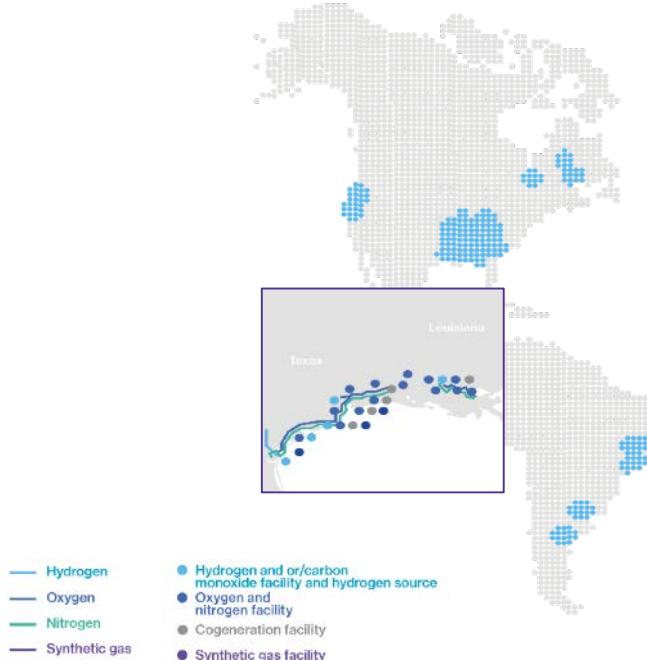
Hydrogen – the pathway with renewables



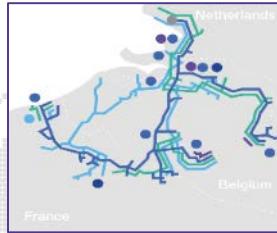
Hydrogen – today's industrial pathway



40 years of global investment in hydrogen



> 14 bn m³/yr
> 1,850 km H₂ pipeline
> 46 large H₂/CO plants
> 2 bn € sales
year 2015



Production



Distribution



Applications



November 26, 2018

Air Liquide to build first world scale liquid hydrogen production plant dedicated to the supply of Hydrogen energy markets

Air Liquide will build the first world scale liquid hydrogen production unit dedicated to the hydrogen energy markets, located in the Western U.S., and has signed a long-term agreement with FirstElement Fuel Inc (FEF), a leader in retail hydrogen infrastructure in the U.S., to supply hydrogen to FEF's retail liquid hydrogen fueling stations in California. These new commitments will serve the growing needs of the hydrogen mobility market in California and help enable and complement the deployment of hydrogen fuel cell electric vehicles and support the hydrogen merchant market across the state.

Liquid Hydrogen - Production

CLEAN MOBILITY
by  **Air Liquide**

Air Liquide's Western U.S. RLH₂ Investment



1ST @scale renewable liquid hydrogen dedicated to the H₂ E markets

\$150 MM anticipated investment

- Capacity : 30 tons per day
- Production : Steam methane reforming
- Key Figures
 - Location: Western U.S.
 - Construction to begin early 2019
 - Operations & delivery by 2021
 - \$150 million USD investment

Liquid Hydrogen - Production

Air Liquide selects Hydrogenics for 20MW electrolyzer for hydrogen production; largest PEM electrolyzer in world

26 February 2019

Air Liquide will **build** in Canada the largest PEM (Proton-Exchange Membrane) electrolyzer in the world with a 20 megawatts (MW) capacity for the production of low-carbon hydrogen (the facility will use **hydropower**).

Air Liquide will **install** a 20 MW electrolyzer that increases by 50% the current capacity of its hydrogen facility located in Bécancour, Québec. The facility is expected to be in commercial operation by the end of 2020, with an output of just under 3,000 tons of hydrogen **annually**.

Station Characteristics



- **Vehicles & User**

- 4-5 kg/fill
- 3-5 minutes per fill
- H70

- **Station Usage**

- 100+ vehicles/day/position
- 1-4 fueling positions/station
- 1 nozzle/fueling position

- **Capacity**

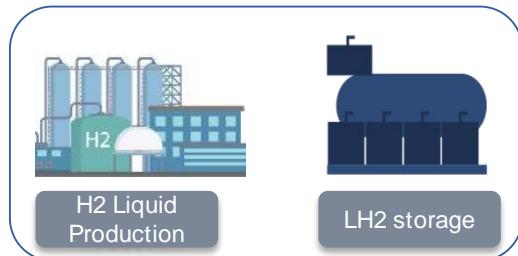
- Today: 300 kg per day
- Future: may exceed 1000 kg per day

Delivery Options



- Gaseous supply chain (300-450 bar)
- Onsite gaseous production
- Liquid supply chain

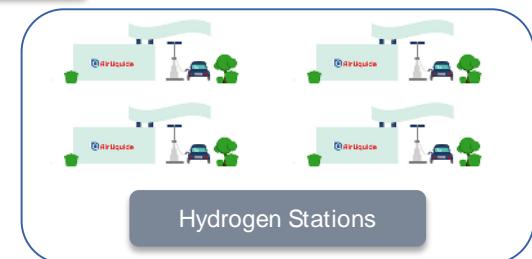
From Today's Distribution Model...



Production & Liquefaction

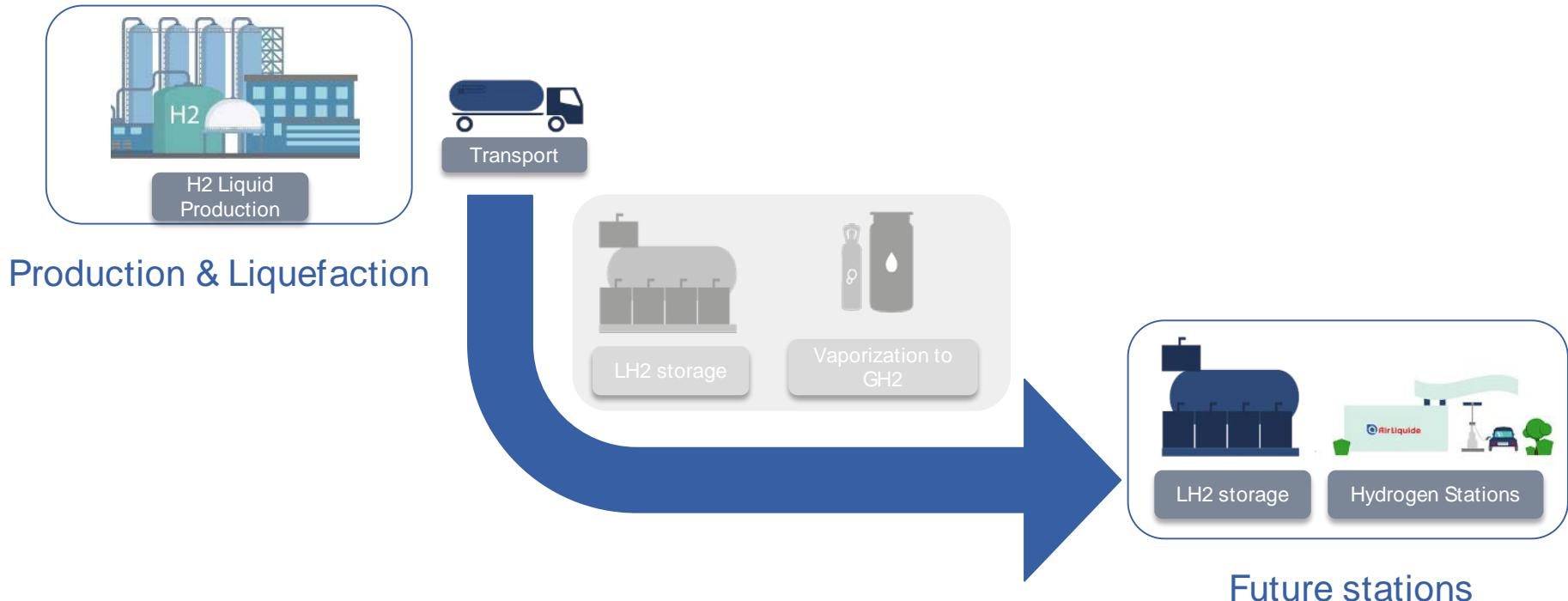


Hub



Station Network

...To Tomorrow's Distribution Model



Gaseous Hydrogen - Transport & Storage



- Industry standard trailer: 300 kg of H₂, 2400 psi
- Air Liquide tube trailer: 440 kg of H₂, 6500 psi
- Underground Hydrogen Cavern
 - Beaumont, TX
 - Nearly one mile wide and 230 ft deep
 - Enough hydrogen to back-up a SMR for 30 days



Liquid Hydrogen - Transport & Storage



Onsite Liquid Storage

15,000 gallons is the typical storage
= 4 tons



Liquid Delivery Tanker

13,000 gallons in the typical tanker =
3.5 tons



NASA Sphere

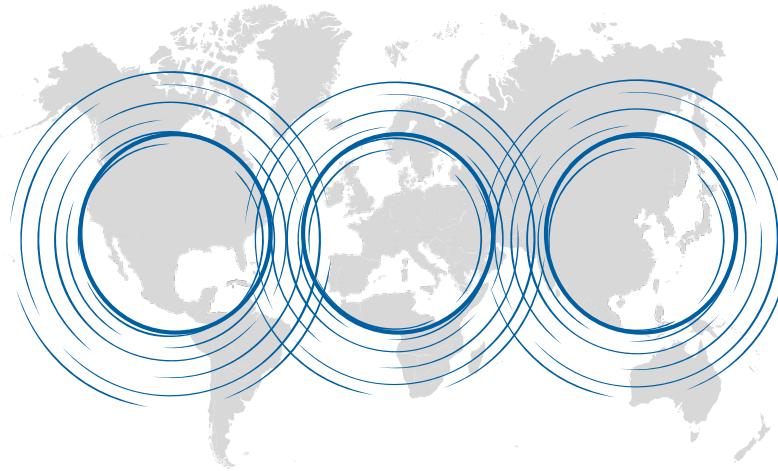
Built in the 1960's containing
850,000 gallons = 230 tons

Liquid Hydrogen - Liquefaction



- **Onsite Liquefaction**
 - 1 - 3 tons per day
- **Typical Industrial Liquefier**
 - 10 - 30 tons per day
- **Future Liquefier**
 - 100+ tons per day

Looking beyond...



PRESS RELEASE

Paris, February 25, 2019

Air Liquide invests in the world's largest membrane-based electrolyzer to develop its carbon-free hydrogen production



PRESS RELEASE

November 26, 2018

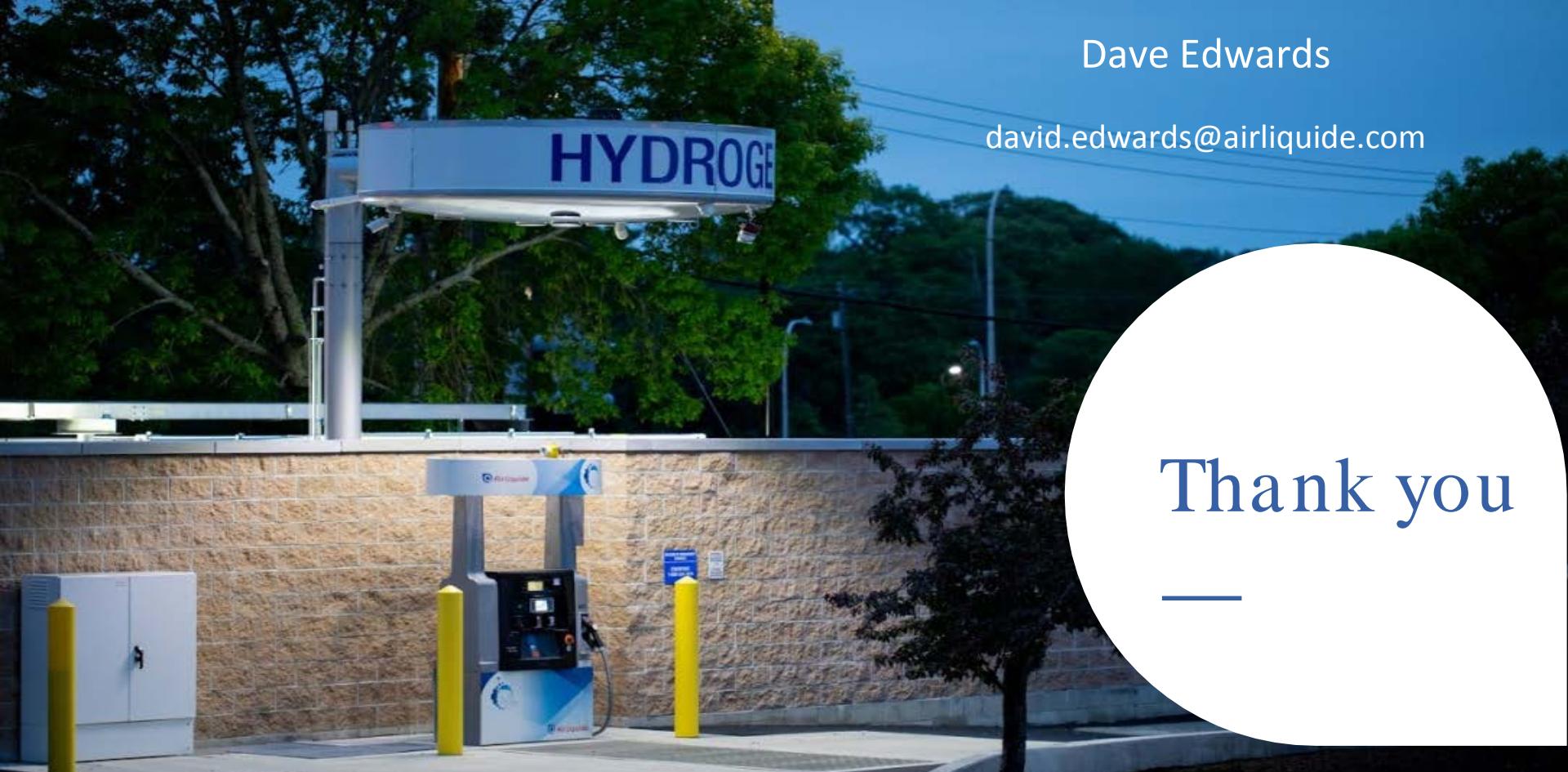
Air Liquide to build first world scale liquid hydrogen production plant dedicated to the supply of Hydrogen energy markets



PRESS RELEASE

January 24, 2019

Air Liquide makes a strategic investment in the production of decarbonated hydrogen by electrolysis



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Thank you