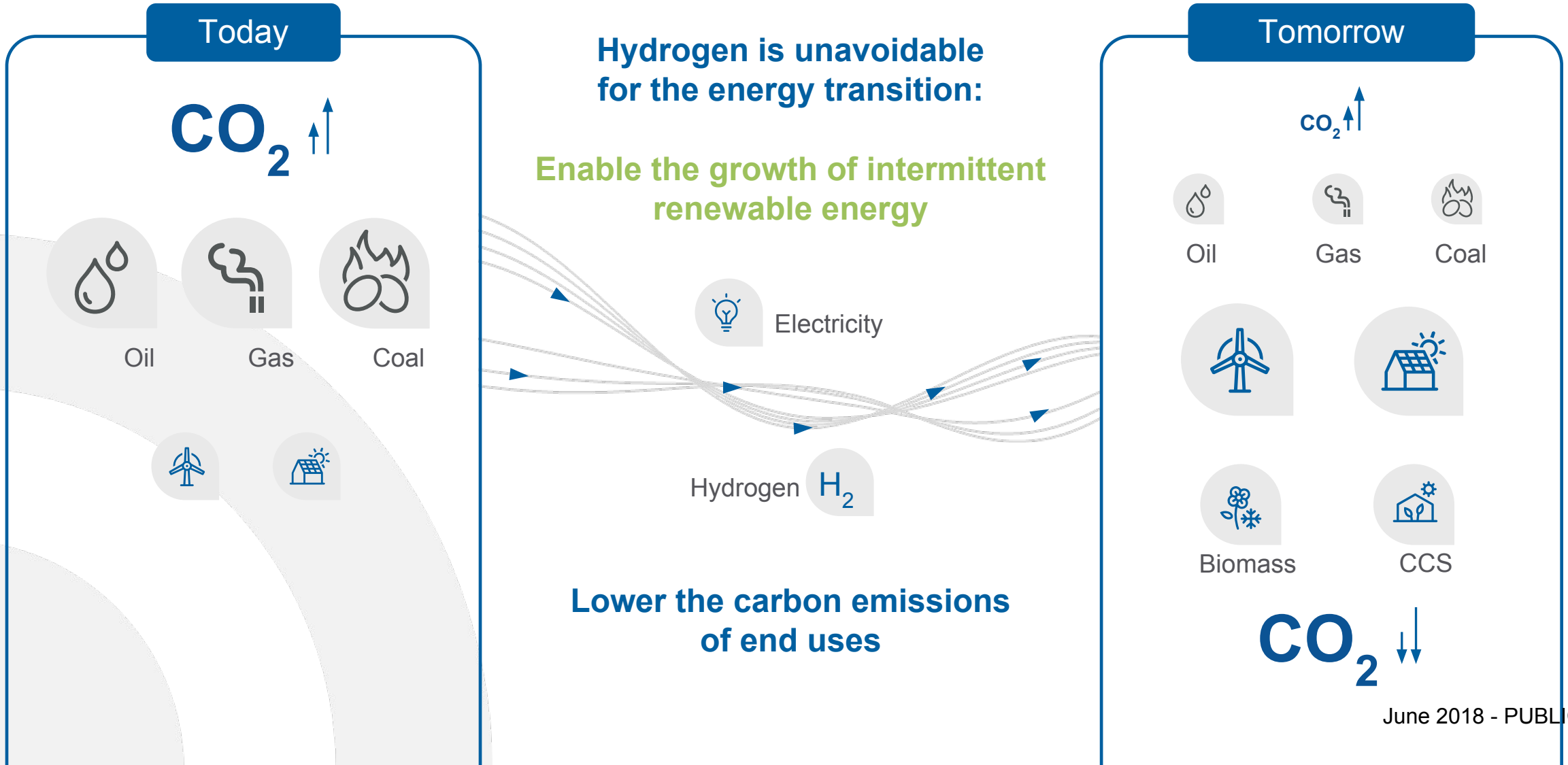
Air Liquide

H_2 Energy

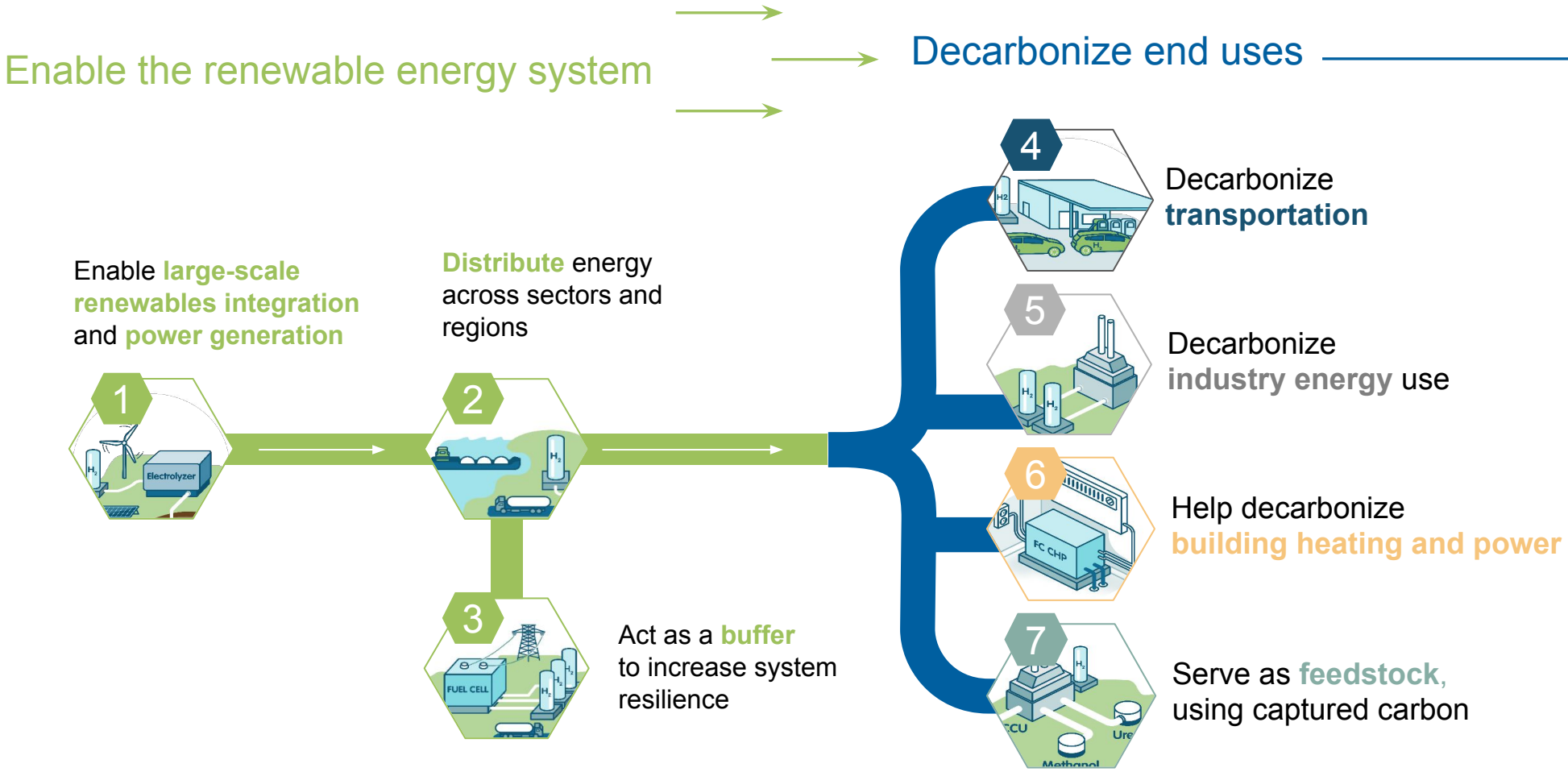
At the heart of the energy transition

Gdynia 25/10/2018

Transformations in the global energy system

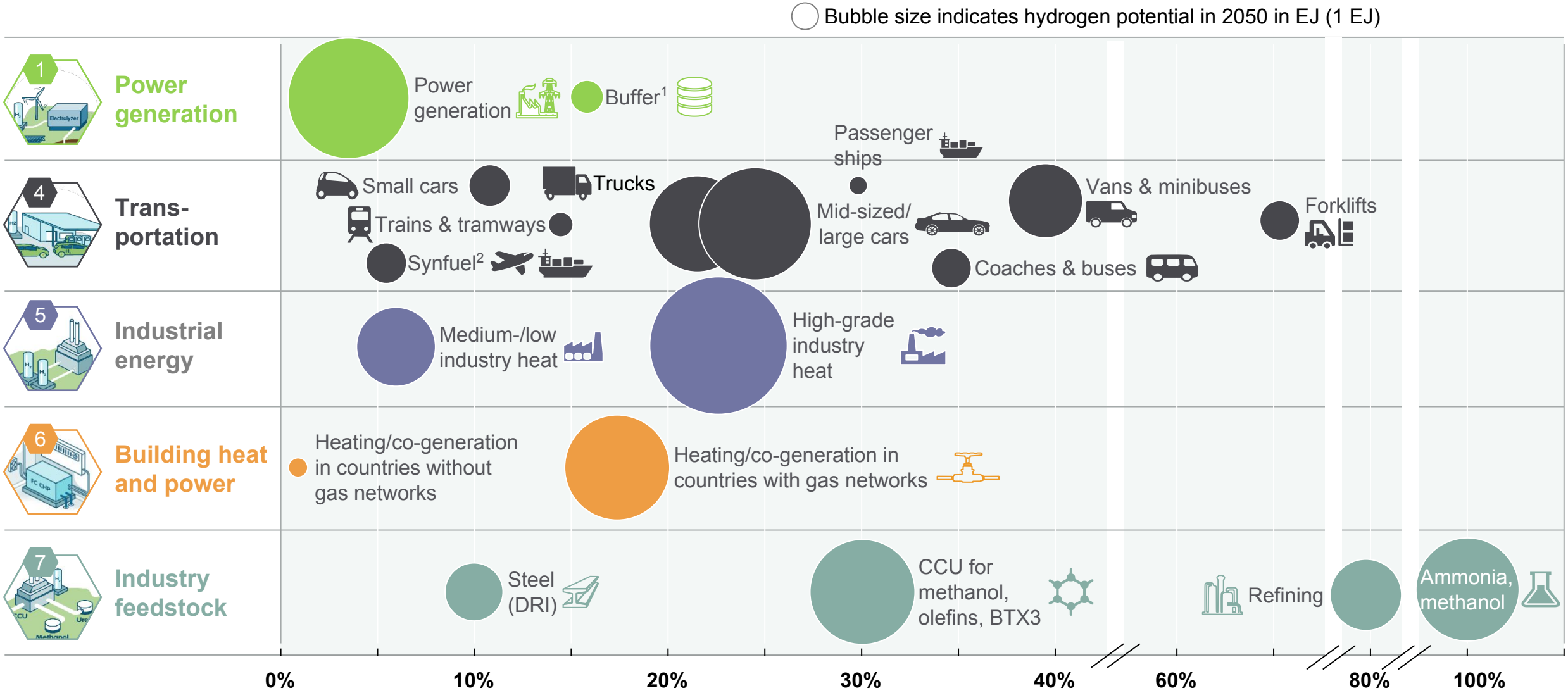


There are seven roles for hydrogen in the energy transition



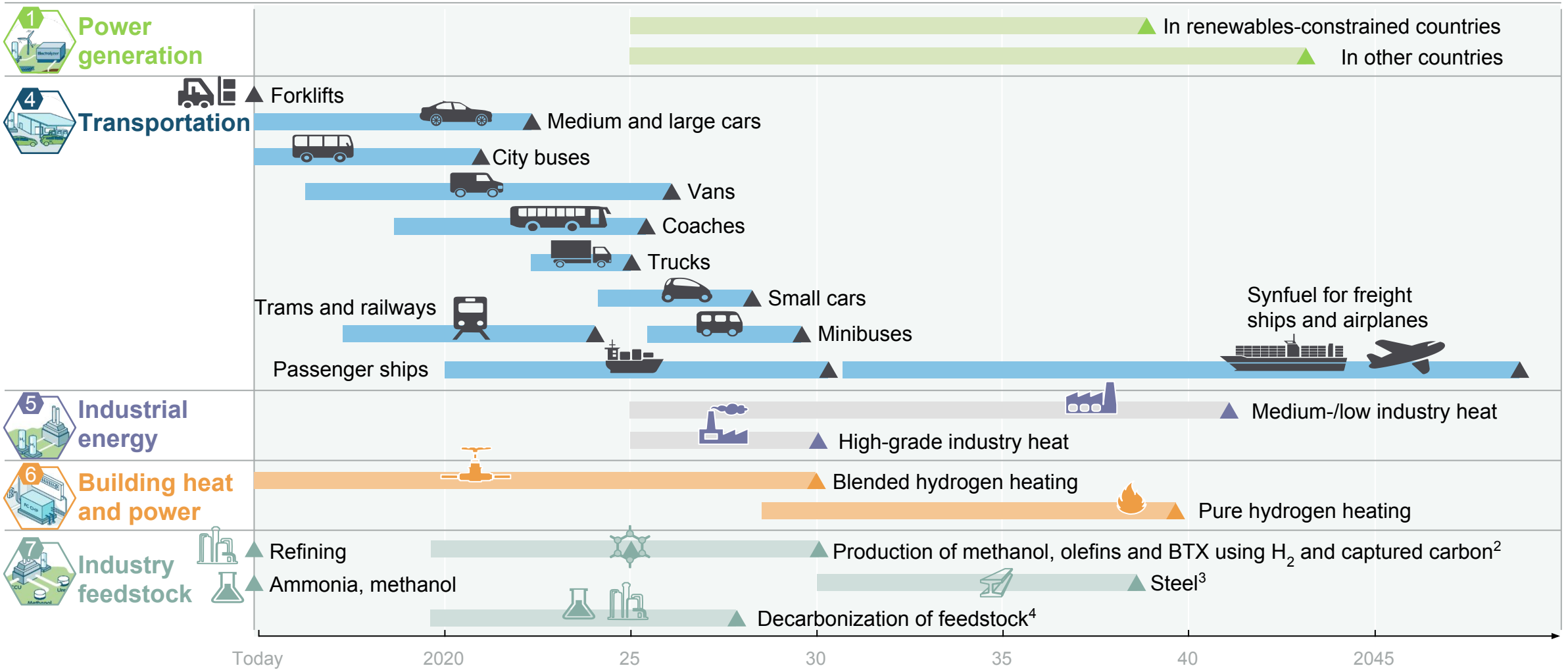
Source: McKinsey & Hydrogen Council 2017

Hydrogen has significant potential across all applications



Source: McKinsey & Hydrogen Council 2017

The technologies exist and are ready to be deployed



1 Mass market acceptability defined as sales >1% within segment in priority markets
2 Market share refers to the amount of production that uses hydrogen and captured carbon to replace feedstock
3 DRI with green H2, iron reduction in blast furnaces and other low-carbon steel making processes using H_2
4 Market share refers to the amount of feedstock that is produced from low-carbon sources

Source: McKinsey & Hydrogen Council 2017

Start of commercialization : Mass market acceptability[1]

Hydrogen by 2050:
a quantified vision of its key role in the energy transition

18%
of final energy demand

30 million
jobs created

6 Gt
annual CO_2 abatement

$2 500 Bn
annual sales
(hydrogen & equipment)

Source: McKinsey & Hydrogen Council 2017

Hydrogen mobility markets:
Ready to scale TODAY

Ferries
1 T/day

Cruise ships
10 T/day

Material handling vehicles
100 kg/day per site

Trucks
100 kg/day per truck

Buses
20 kg/day per bus

Trains
150 kg/day per train

Individual cars
100-200 kg/day per station

Drones

Airplanes Applications

Bicycles & scooters

Air Liquide already started to invest

Mobility for Professionals
US+EUROPE
9 HRS

Mobility for Consumers
US North-East
12 HRS
+ Supply chain

Mobility for Consumers
California
4 HRS

Mobility for Consumers
Japan
6 HRS

Mobility for Consumers
Dubai
1 HRS

Mobility for Consumers
Korea
1 HRS

Power to Gas
Denmark
5 HRS
+ 1 Electrolyzer

Mobility for Consumers
Germany
11 HRS

Mobility for Consumers
Paris, Brussels and Rotterdam
5 HRS

14 bn m^3/yr

1,850 km H_2 pipelines

46 large H_2/CO plants

40 electrolyzers in operation

2 bn € sales

100 Hydrogen recharging stations (HRS) installed by Air Liquide in the world in which 40 directly invested and operated by Air Liquide

Germany as an example for AL activities:
H2 MOBILITY Joint Venture

In 2015, Air Liquide joined forces together with its partners **Daimler, Linde, OMV, Shell and Total** and founded the joint venture **H2 MOBILITY Deutschland GmbH & Co. KG**.

So that progress dovetails as closely as possible with the automobile industry, **BMW, Honda, Hyundai, Toyota and Volkswagen** are on board as **associated partners**.

In October 2018, **Great Wall Motor (GWM)**, one of the leading Chinese car manufacturers, signed a Memorandum of Understanding to join H2 MOBILITY as seventh shareholder.

H2 MOBILITY will expand the existing network of hydrogen stations in Germany to up to 400.

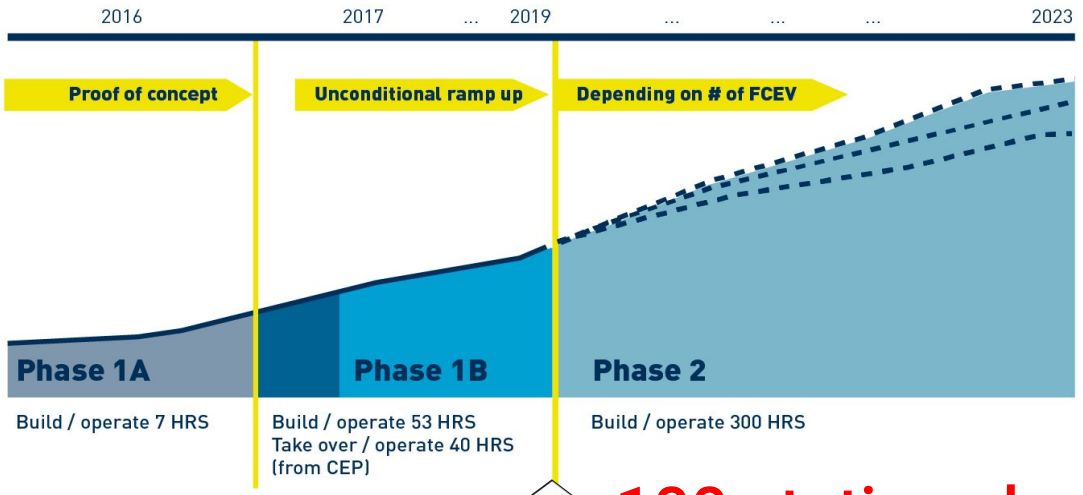
- First interim goal: 100 H2 stations in metropolitan areas and along t motorways by 2019
- Followed by another 300 stations as the vehicle numbers are ramped up.

The stations are preferably **integrated into existing conventional service stations**. Their design is compact and relies mainly on standard components for the fuel pumps, the hydrogen storage, and the compression.

H2 MOBILITY receives funding from the German Federal Ministry of Transport and Digital Infrastructure (BMVI) as part of the National Innovation Programme for Hydrogen and Fuel Cell Technology (NIP) as well as from the European Commission in the Hydrogen Mobility Europe project, which receives funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (FCH 2 JU, grant agreement no. 671438). The FCH JU is supported by the European Union Framework Programme for Research and Innovation (Horizon 2020), Hydrogen Europe and the Hydrogen Europe Research Association.

Germany:
H2 MOBILITY: A fully operational company

Mission: the **quick, efficient development** of the hydrogen infrastructure needed for fuel cell vehicles, in order to provide **nationwide coverage.**



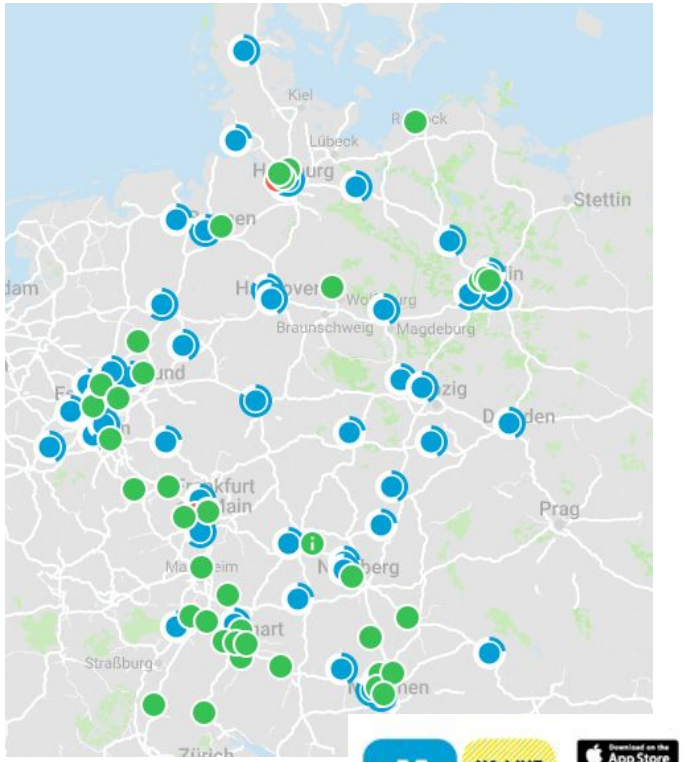
20 stations in 2015

100 stations by 2019

Germany:
Building a comprehensive hydrogen network

Status: **As of October 2018, Germany had a total of 53 H2 refuelling stations**

- 10 stations thereof invested and initially operated by AL under the roof of CEP
- 8 out of these 10 stations (all except Düsseldorf-Höherweg and Cologne-Frechen) taken over by H2 MOBILITY in H1 2018
- 7 stations thereof with AL technology, invested and since the very beginning operated by H2 MOBILITY
- **Thus in total 17 stations with AL technology in operation**
- Real time information via the H2 Live App



Outlook: The network is constantly growing

- 1 additional station invested and to be initially operated by AL under execution
- 20 additional stations invested and operated by H2 MOBILITY with AL technology under execution
- **Thus in total additional 21 stations with AL technology under execution**

H2.LIVE takes me further

H2.LIVE – the app for clean drivers or on the web: H2.LIVE

Germany:
H2 MOBILITY stations with AL technology

Stations in operation I

Frankfurt am Main (with Shell)

Opened in June 2017

Wendlingen (with Shell)

Opened in December 2017;
officially inaugurated in February 2018

Ingolstadt (with TOTAL)

Opened in December 2017;
officially inaugurated in March 2018

Germany:
H2 MOBILITY stations with AL technology

Stations in operation II

Lohfelden (with Shell)

Opened in July 2018;
officially inaugurated in August 2018

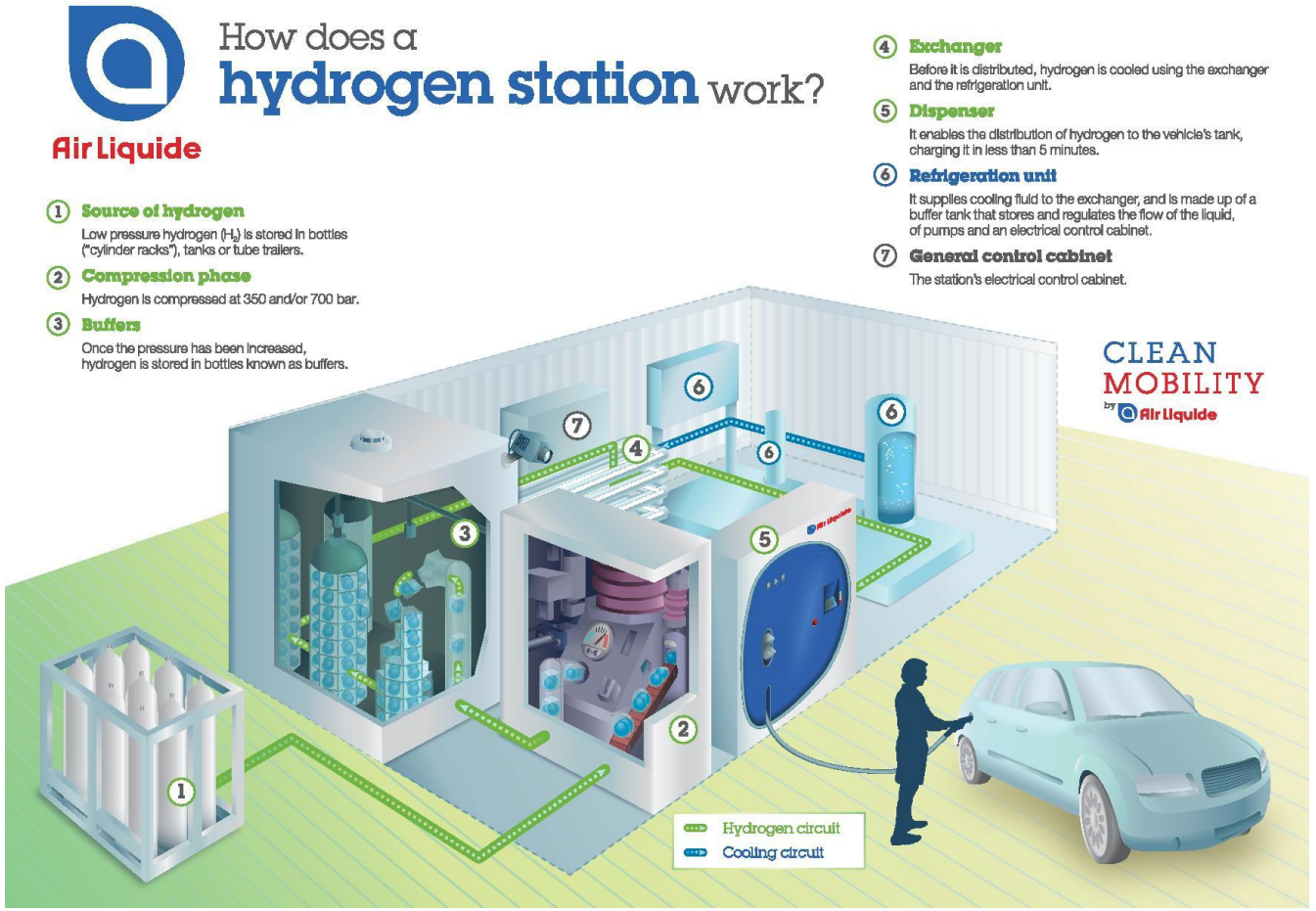
Ratingen (with Shell)

Opened in September 2018;
scheduled to be officially inaugurated in spring 2019

Mülheim (with Star/Orlen)

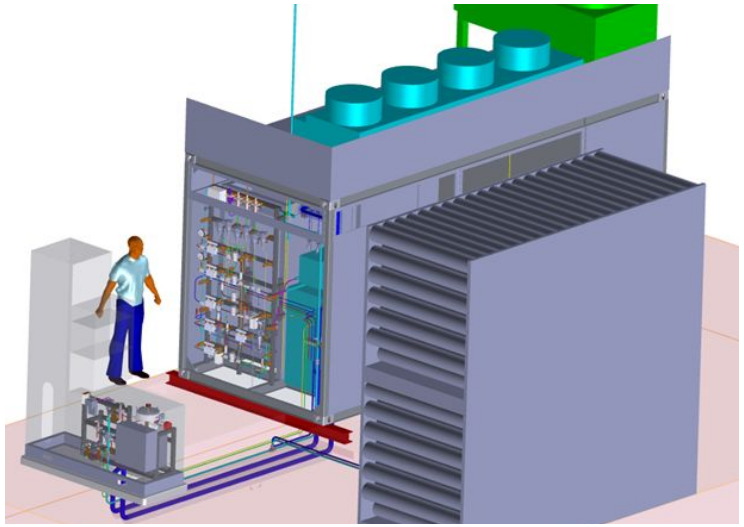
Opened in May 2017

Refuelling at Air Liquide: How it works

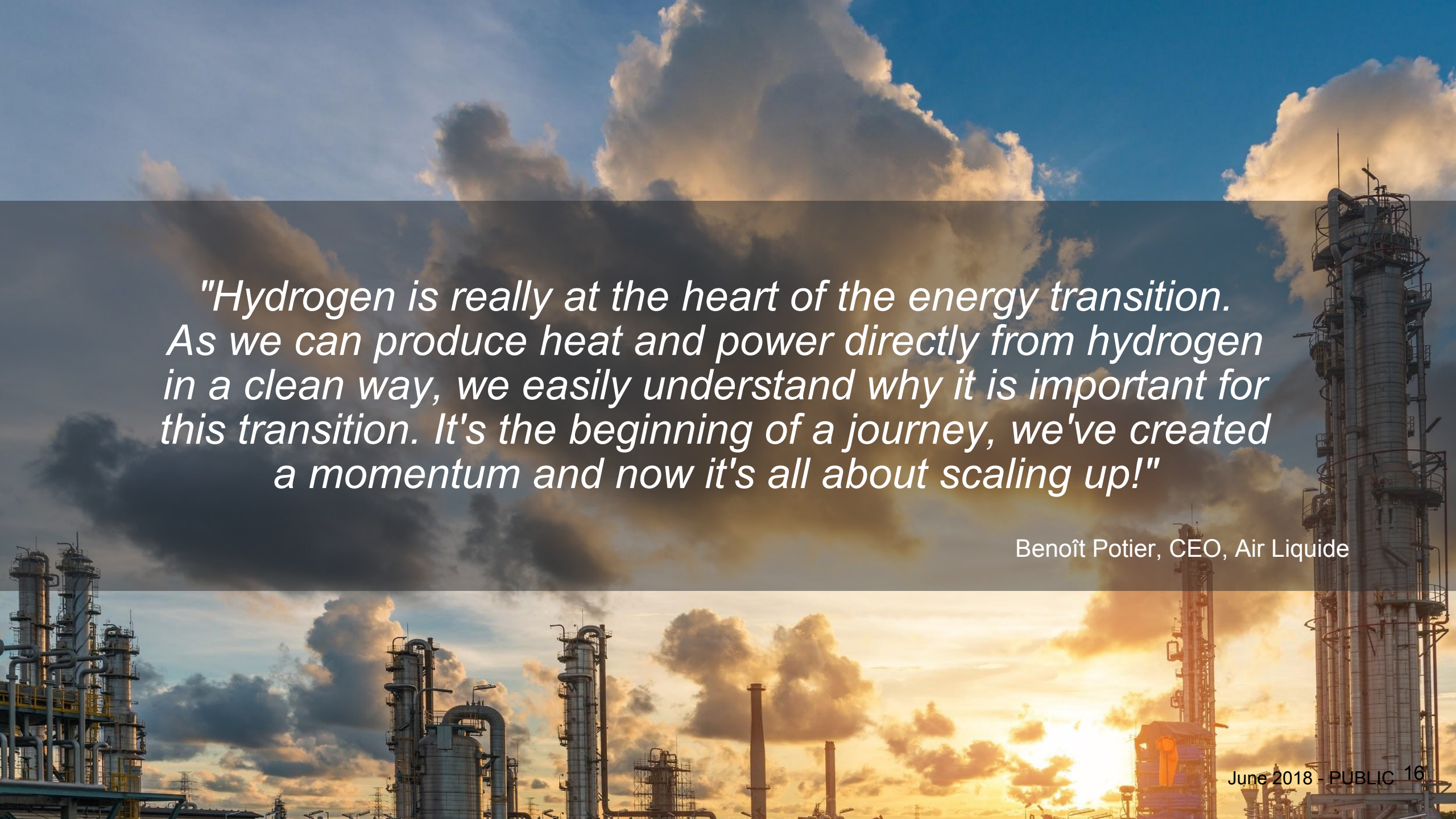


Third generation of AL H2 stations: G3

First G3 station in Germany (and Europe) has been Ratingen (near Düsseldorf, with Shell), opened in Q3/2018



more compact / simplify the system
less civil work required
typical site-footprint = 80 - 100 m²



"Hydrogen is really at the heart of the energy transition. As we can produce heat and power directly from hydrogen in a clean way, we easily understand why it is important for this transition. It's the beginning of a journey, we've created a momentum and now it's all about scaling up!"

Benoît Potier, CEO, Air Liquide