Our lives in the city of the future will become cleaner, healthier, and more efficient due to hydrogen-powered digital technologies



## Autonomous taxis are becoming a reality



Autonomous taxis and shuttles<sup>1</sup>, million units

1 Shuttles = shared robotaxis with pooled demand

SOURCE: Bloomberg; expert interviews; GM; IHS Automotive; press reports; Uber; Waymo

~USD 15-20 bn

investments in the past 5 years

# 16+ m test kilometers

in level 4 autonomous cars

# 10+ OEMs

planning for level 5 autonomous cars by 2025

Hydrogen as energy vector for autonomous taxis enables zero emission operation without long stops for battery charging

Example: airport shuttle





# Refueling time required for FCEV ~5 minutes per day 9 PM-9:05 PM Pause for the refueling 0 S PM-12 M Taxi operation 6 AM - 9 PM Taxi operation

Hydrogen as an energy vector for autonomous taxis and shuttles requires less space for refueling infrastructure

Example: New York City cabs<sup>1</sup>

Charging stations for all NYC cabs would take up space equal to ...



1 Number of taxis and cabs: ~74,000; annual mileage per taxi 70,000 miles; refueling times FCEVs 0.02 minutes/mile, BEVs 0.26 minutes/mile; area for one fueling station 30 m<sup>2</sup>; size of NBA court (436 m<sup>2</sup>; 28.7 x 15.2 m)

SOURCE: EPA; Curbed New York; NBA; New York City Taxi and Limousine Commission; Tesla

# Quickly growing home deliveries require energy that is zero-carbon and emission-free

![](_page_4_Figure_2.jpeg)

Growing e-commerce and clean cities

- Booming e-commerce and growing demand for delivery speed
- Cities take action against local emissions
- Freight operations along the entire value chain need to be green

## Hydrogen can efficiently move goods from the warehouse to the door

Hydrogen technology status

![](_page_5_Figure_3.jpeg)

# Hydrogen as an energy vector for long-haul trucks requires less weight for the powertrain

Powertrain weight comparison,

in tons (18-ton tractor unit of a semitruck)

![](_page_6_Figure_4.jpeg)

Hydrogen tanks have 10 times

the energy density (by weight) than batteries<sup>1</sup>

1 0.2 kWh/ kilogram for rechargeable batteries used in battery electric vehicles (BEV) compared to 2.2 kWh/kilogram for onboard hydrogen storage for lightduty fuel cell vehicles (FCEV); Source: U.S. DOE Office of Energy Efficiency and Renewable Energy, MCFM

SOURCE: DOE; Nikola Motors; Bloomberg; Manager Magazin; Sustainable Transportation Lab

Hydrogen as an energy vector for long-haul trucks enables storage of large amounts of energy at lower costs than batteries

System costs of battery vs. hydrogen, USD thousands

![](_page_7_Figure_3.jpeg)

# ~100 kilometers:

the threshold range for hydrogen trucks to become cheaper than battery trucks

SOURCE: DOE; Hydrogen - scaling up

## Hydrogen as an energy vector for VTOLs allows for longer routes without recharging

![](_page_8_Picture_2.jpeg)

Data centers, as the backbone of all digital trends, require large amounts of green energy

Energy demand, TWh

![](_page_9_Figure_3.jpeg)

# 35%

annual growth of data center storage from 2016 to 2021

# 30-50%

of data center costs are attributed to energy, mostly for cooling

SOURCE: Bloomberg; Cisco; Digital Realty; Enerdata; expert interviews; Forbes; Gartner; IEA; Intellect UK; zdnet

# For the four selected use cases, hydrogen demand could grow to 5-7 m tons by 2030

In 2030, hydrogen could power ...

![](_page_10_Figure_3.jpeg)

Hydrogen as an energy vector for autonomous taxis and shuttles allows for high uptime (long ranges and fast refueling)

Example: airport shuttle

![](_page_11_Figure_3.jpeg)

SOURCE: EPA; Hyundai; New York City Taxi and Limousine Commission; Tesla; McKinsey Powertrain model; Tesla