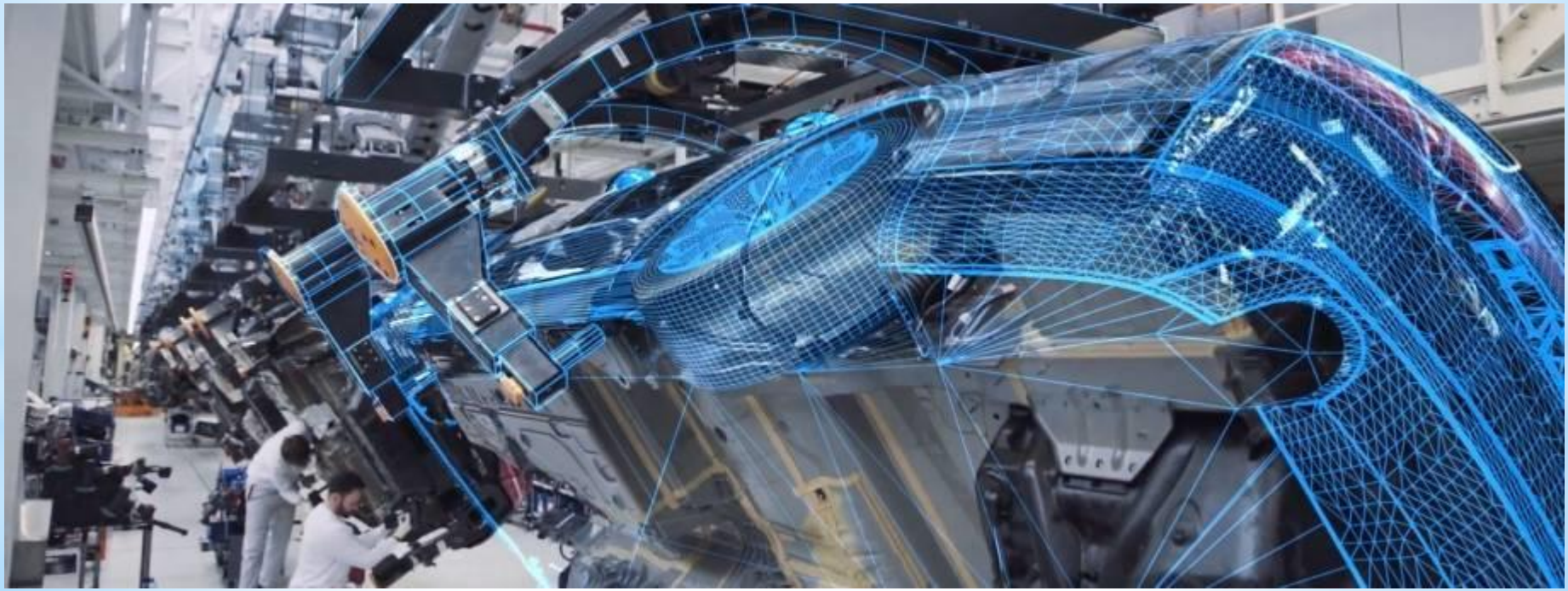
# The Future of Transport



# Introduction

1. **Transport** will be revolutionised in this decade with radical new inventions powered by **renewable energy.**
2. We're about to see the pace of change revving up dramatically.

# Why transport needs to change?

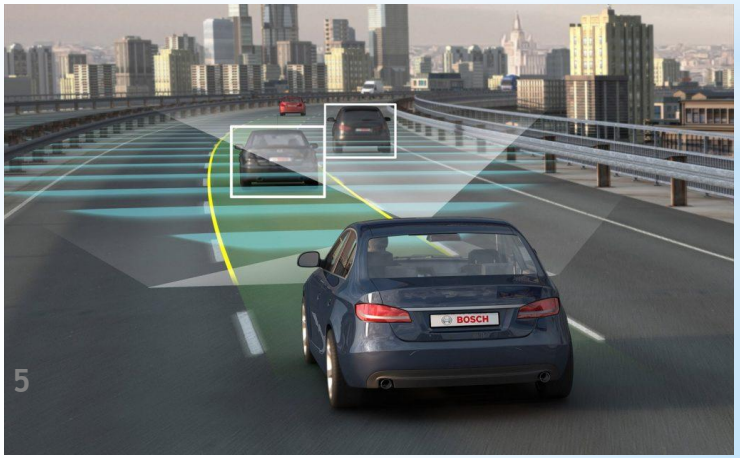
1. **Henry Ford's** 'car for the great multitude' changed ordinary people's daily lives.
2. But the **consequence of this mass adoption** has led to pollution and city congestion.

# Change imminent (1)

1. We’re already experiencing the **beginning of a revolution in transport** with car sharing schemes, electric vehicles **(EVs)**, electric scooters, drones and even autonomous buses are already here.
2. **Delivery by drone** is one of the immediate next advances, intended to reduce delivery van congestion and pollution.

# Change imminent (2)

2. The transition to **EVs** is also accelerating rapidly.
3. Sale of new petrol and diesel cars will be **banned** by 2030 in the UK, **New York has also announced** that sales of nearly all gas- and diesel-powered cars will be banned by 2035.

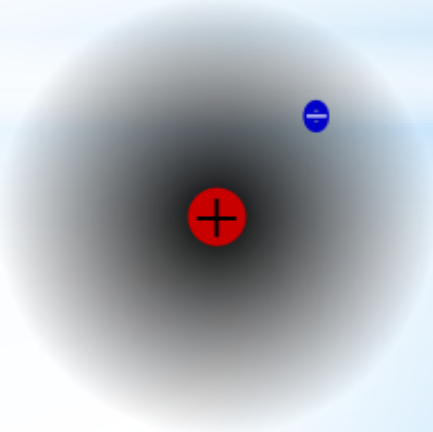



# Fuels for the future (1)

1. **Petroleum** was first discovered in 1859, but our reliance on this fossil fuel has to end if we're to tackle **climate change**.
2. **Alternative renewable energy sources** will continue to be investigated and implemented:
   - **Electric battery-powered cars** are currently in pole position in the "fuel race".
   - **Biogas** and **hydrogen** are two petrol-alternative.

# Fuels for the future (2)

1. **Biogas** provides an immediately available solution for heavy goods vehicles **(HGVs)** and long-haul ones.
2. **Hydrogen** is potentially and environmentally an ideal fuel. Current challenges for hydrogen at scale are manufacturing it into a useable form for transport.
3. **Hydrogen** may well be the future solution for **HGVs** and long-distance journeys.

# Fuels for the future (3)

1. In the future, it's possible **we'll see large-scale charging hubs** for **HGVs**, buses and public fleet, such as council, all in one location to minimise disruption.


# Autonomous vehicles (AVs) and Artificial Intelligence (AI) (1)

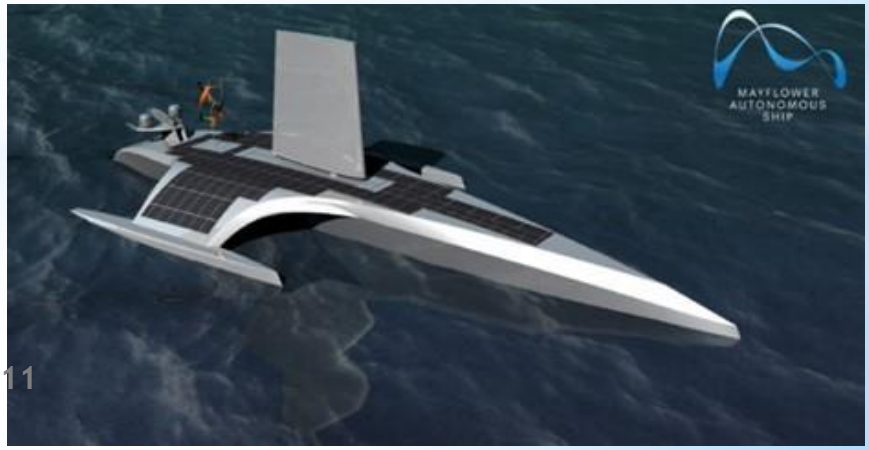
1. **AVs combined with artificial intelligence (AI)** will provide a future of convenience and comfort when it comes to future transport.
2. In the future**, robot vehicles** may look entirely different from the hands-free/big-screen version we expect.

# Autonomous vehicles (AVs) and Artificial Intelligence (AI) (2)

1. **Central AI software** may control urban traffic systems, directing traffic flow so congestion and road accidents are both consigned to history.

# Autonomous vehicles (AVs) and Artificial Intelligence (AI) (3)

1. In the US, **Ford, Argo AI and Walmart are collaborating on a delivery service** located in Austin, Miami and Washington.
2. **Autonomous ships** are expected to be crossing seas in the near future.



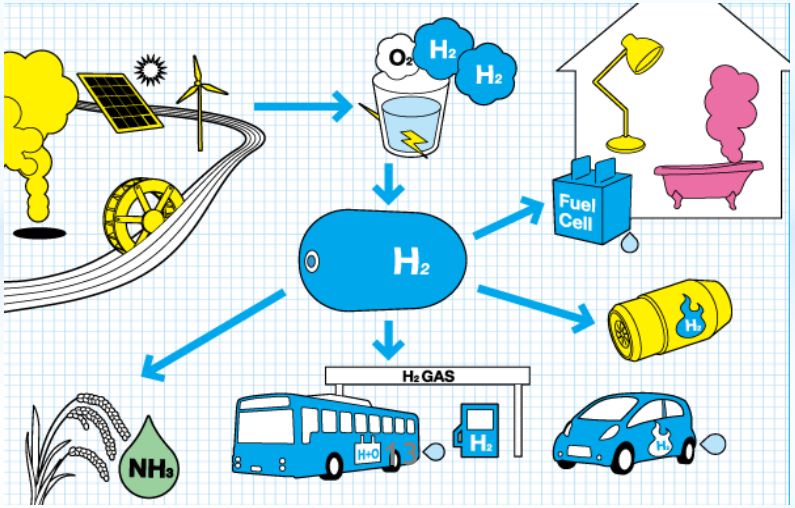
# Super-sonic speeds, Super-sonic Vehicles (SSVs)

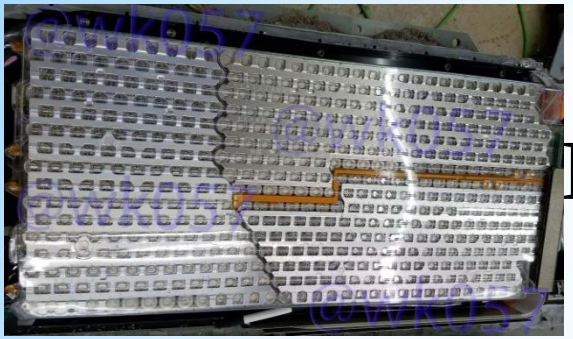
1. Elon Musk called his open-sourced idea for a **Hyperloop** train system “a cross between a Concorde, railgun and an air hockey table”.
2. By 2030, **Virgin Hyperloop** could be whisking people and freight from New York and Washington DC in just 30 minutes


# Hydrogen – main player in the future (MVF as MVP in a sport)

## Introduction

1. The basic prerequisite for the use **of hydrogen** in all relevant sectors is transition to a low- or zero-carbon economy.
2. **The European Union has set itself the goal of achieving complete neutrality climate change by 2050.**





# Hydrogen – main player in the future (MVF as MVP in a sport)

## What energy properties does hydrogen have?

1. **Hydrogen** is a very high-energy fuel (33 kWh/kg).
2. **Tesla batteries** reach an energy density of 0,250 -0,260 kWh/kg.
3. However, each technology has its drawbacks, namely the low volumetric energy density of hydrogen (3kWh/m3 at 20°C and 1 bar).
4. The implication is: a tank that can hold, for example, 6.3 kg of hydrogen has a total capacity approx.150 liters.

# Hydrogen – main player in the future (MVF as MVP in a sport)

## Transport - use of hydrogen (1)

1. **Hydrogen** is the main competitor of battery electric vehicles (**BEV**) and will likely play a key role in the future energy system – particularly in decarbonising hard-to-abate sectors.

2. **Strengths of hydrogen:**
   - Hydrogen-powered cars - Fuel Cell Electric Vehicles (**FCEV**) have a longer range (600 km and more).
   - A short time filling (approx. 5 minutes).
   - They work better in cold conditions,
   - Travel loss at higher speeds is equal to a row of internal combustion cars.

# Hydrogen – main player in the future (MVF as MVP in a sport)

## Transport - use of hydrogen (2)

1. **Weaknesses of hydrogen**:
   - The mass development of **FCEV**s is hindered only by the high purchase price and small infrastructure of filling stations.
   - This problem should be solved by wider use of **FCEV** which will result in a dramatic drop in purchase prices due to mass production.

# Hydrogen and batteries should be two complementary technologies that will complement each other. Why? (1)

## Long distance transport (1.1)

1. The hypothetical technological evolution of batteries (solid cell batteries) and problems to use the increased capacity for journeys over 1,000 km.
2. The current batteries are very heavy. The need is a minimum capacity of 1.5 MW. Unfortunately a weight of battery for transport over longer distances (>1000 km) is of 3 tons.

# Hydrogen and batteries should be two complementary technologies that will complement each other. Why? (1)

## Long distance transport (1.2)

1. **The problem is also charging such a large amount of electricity**. How much power would the chargers have to have to charge a 1.5 MW at night between shifts? For 20 trucks you need small power plant.
2. It is obvious that we can transport the hydrogen to the truck easier and much faster. So hydrogen offers more potential for transporting goods over longer distances now.

# Hydrogen and batteries should be two complementary technologies that will complement each other. Why? (2)

## Transport in cities

1. On the other hand, **in cities, battery electromobility can play a more significant role** due to its high efficiency and low cost.
2. The battery is perfect for city traffic, where operators do not need a long commute. **BEV it is ideal solution for standard everyday driving** and charging at home from the socket.
3. **FCEV**s may also be a suitable alternative for drivers living in densely populated areas without adequate charging options at home.


# Hydrogen and batteries should be two complementary technologies that will complement each other. Why? (4)

## Bus transport

1. The most efficient **solution for urban transport with a battery bus** is a journey of several dozen kilometers, just like in a city bus freight transport.




# Hydrogen and batteries should be two complementary technologies that will complement each other. Why? (5)

## Railway transport

1. **Hydrogen can replace diesel rail transport** in parts of countries, where there is no electrified railway.

# Clean hydrogen potential and timing per sector

| Sectors | | Role of clean hydrogen | | Timing | | |
|---|---|---|---|---|---|---|
| | | | | 2030+ | 2040+ | Rationale for high potential sectors |
| Industry | Steel | H | Reduction agent for DRI or BF-BOFII and for high temperatures | ~ | √ | Possible natural demand for flat steel (by OEMsIII), but low 'willingness to pay' and long asset replacement cycles |
| | Ammonia | H | Feedstock to produce ammonia | √ | √ | Possible voluntary demand for food (green 'farm-to-fork'), and ease of asset replacement |
| | Methanol | H | Feedstock to produce methanol | √ | √ | Possible voluntary demand for methanol in shipping, ease of asset replacement, and emerging regulations |
| | Refining | H | Feedstock for hydro-cracking and -treating | √ | √ | |
| | Other chemicals | M | Feedstock and / or fuel for steam cracking | ~ | ~ | |
| | Cement | L | Booster fuel to increase calorific value, but competes with low-cost biomass as fuel | X | ~ | |
| | Other industry | L | Most can be directly electrified / niche applications | X | ~ | |
| Mobility | Road freight | H | Fuel in heavy-duty long-haul transport | √ | √ | Possible voluntary demand, higher 'willingsness to pay', emerging regulation and short asset replacement |
| | Deep-sea | H | Fuel in international shipping in the form of hydrogen, ammonia or methanol | ~ | √ | Possible voluntary demand (low cost impact in container shipping), but low technology alignment and long asset replacement cycles |
| | Aviation | H | Direct use or as feedstock to produce Sustainable Aviation Fuel (SAF) | √ | √ | Possible voluntary demand (e.g., in business travel), no asset changes needed, and emerging regulation |
| | Trains | M | Fuel to replace diesel-engine trains in long-haul transport | ~ | ~ | |
| | Cars | L | Electrification possible and more economic | X | X | |
| Build | Residential | L | Heating alternative in case of economic limitations of electrification (e.g., high cost to electrify buildings with poor insulation) | X | ~ | |
| | Commercial | L | | X | ~ | |
| Power | | M | Balance intermittency from renewables through energy storage | X | ~ | |

*) Deloitte – Hydrogen making it happen (report)

High Medium Low

# What is necessary to go forward with decarbonisation of transport?

## Summary (1)

1. **Natural demand**: Addressing natural demand (i.e., demand emerging without regulatory support in specific sectors) through new ‘green’ value propositions.
2. **Regulation**: Adopting simple and synchronised regulations across supply and demand – based on a new nomenclature and certification around the emission intensity of hydrogen.
3. **Technology**: Aligning on the decarbonisation technologies to adopt within each sector, and maturing them quickly, will dictate the speed of demand pick-up for clean hydrogen.

# What is necessary to go forward with decarbonisation of transport?

## Summary (2)

4. **Assets, infrastructure and supply**: Faster asset cycle changes are needed on the demand side, coupled with infrastructure re-use where possible, with large-scale investment in renewable capacity, grids, and infrastructure.
5. **Collaboration**: Collaboration is essential for clean hydrogen production, with new commercial and business models to address the systemic challenges and inertia that can delay investments.

# Thank you very much for your kind attention

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