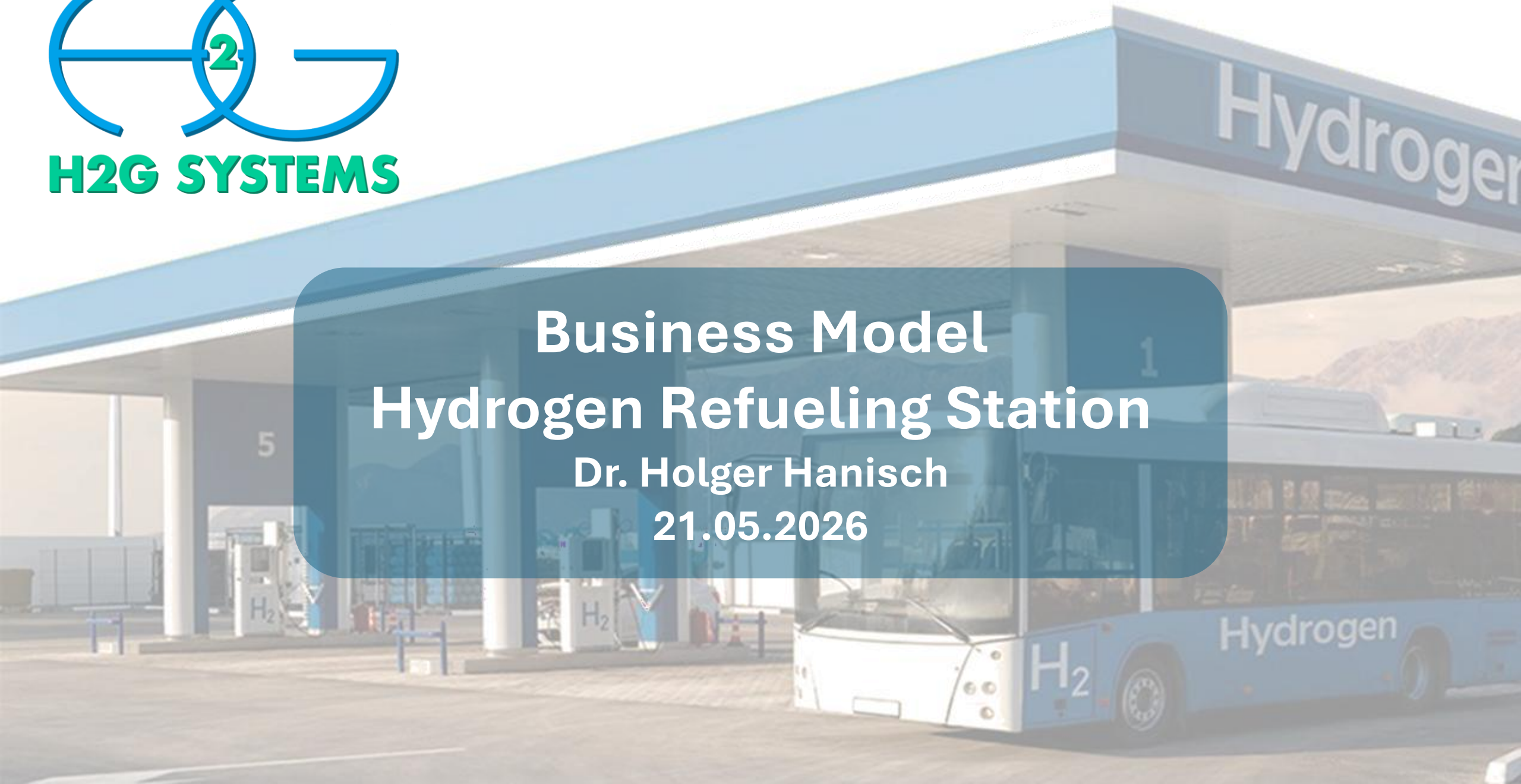




Business Model Hydrogen Refueling Station

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Market Potential - Hydrogen As Future Fuel For Mobility?

Factors for Business Modell

Expenses

- Investment costs
- Operating costs
- Costs of hydrogen

Earnings

- Sales to customers
- Subsidies & GHG-quota sales
- Auxiliary services

Today:

- ⇒ No concrete figures
- ⇒ But discussion of factors



Market Potential - Hydrogen As Future Fuel For Mobility?

Advantages on Generation Side

All sustainable fuels that are not based on biomass are based on hydrogen

- Hydrogen = sun / wind + water
- Methanol = hydrogen + carbon
- Ammonia = hydrogen + nitrogen

Biomass:

- Limited in quantity
- Conflict tank vs. table

Compared to conventional fuels:

- Decentralized – not explored, but generated
- Climate-neutral

Compared to BEV:

- Energy does not have to be generated during time of charging
⇒ H2 can be generated anytime, and can be stored over longer periods at relatively low costs
- Energy does not have to be generated in vicinity to the charging point –
⇒ H2 can be generated anywhere and be shipped over long distances, without requirements for grids



Market Potential - Hydrogen as future fuel for mobility?

Advantages on Utilization Side

- Only fuel that can practically be used in fuel cells
 - ⇒ Fuel cell only option to „burn“ fuel without generating NOx and by-burn of lubricants
 - ⇒ Fuel cell with higher efficiency than internal combustion engines



<https://dwv-info.de/>

- Can also be used in internal combustion engines



<https://allianz-wasserstoffmotor.de>



Market Potential - Hydrogen as future fuel for mobility?

Disadvantages

- High costs of fuel cell systems
- Difficult handling, storage & transport
 - High pressure
 - Low temperature
 - Hydride metals or similar materials
- All hydrogen handling & storage options
 - Expensive
 - With poor weight & space to energy ratio (ca. 20 to 1)

40ft container for hydrogen transport:

- Storage pressure 500 bar
- H₂ Capacity @15°C: 1,103 kg
- Total weight 26,700 kg



Market Potential - Hydrogen as future fuel for mobility?

→ Likely no single dominant fuel in the future

→ Hydrogen with good potential for commercial vehicles





Investment Needs & Operating Costs

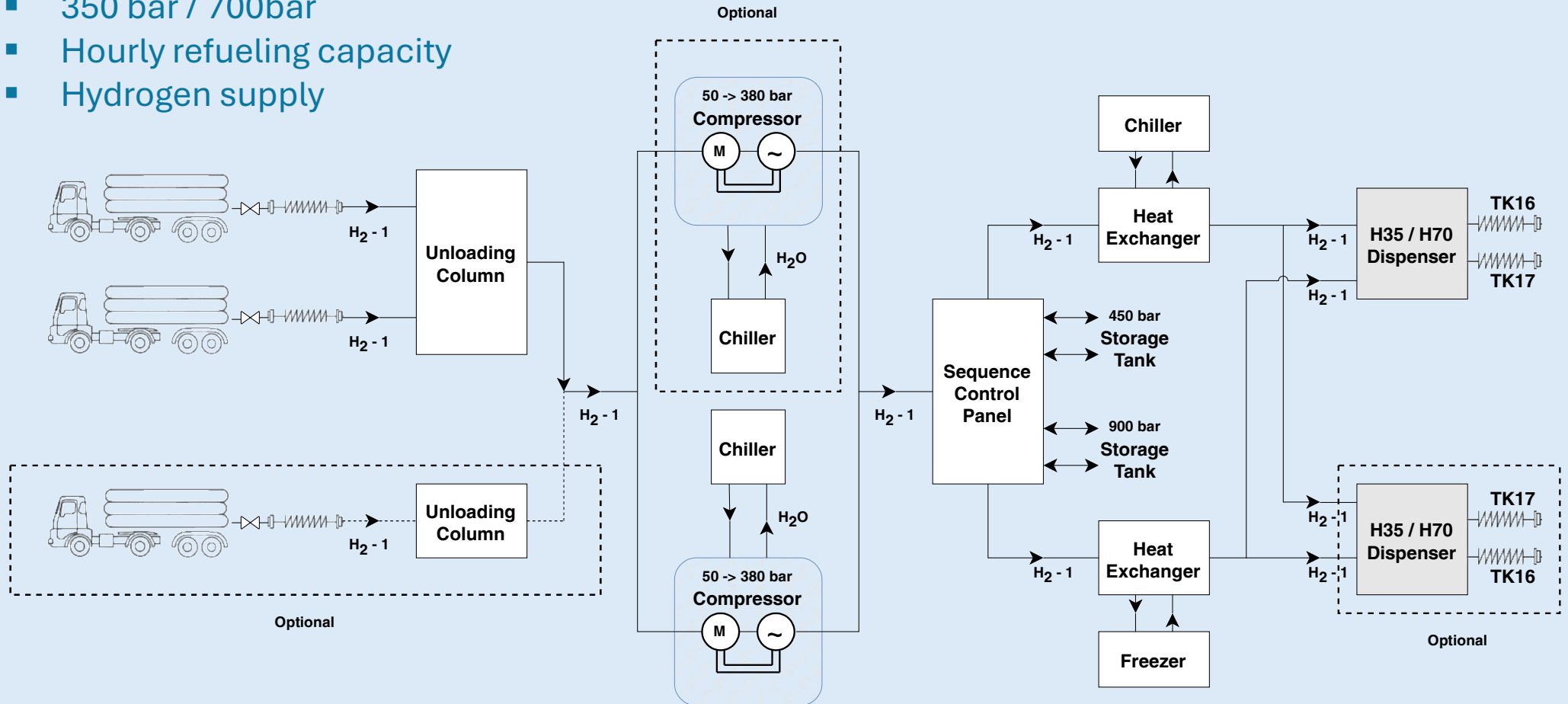
- Considerable CAPEX
 - CAPEX depends heavily on actual configuration of the HRS
⇒ From ca. EUR 750,000 to several million EUR
 - Higher maintenance costs than conventional stations
 - Lower availability due to higher technical complexity
 - No standard prices in the market yet
- ⇒ Need for thorough planning and comparison



Hydrogen Refueling Stations - Configuration Options

Main considerations:

- Stationary or mobile
- 350 bar / 700bar
- Hourly refueling capacity
- Hydrogen supply





Permitting Requirements

- General emission protection regulations / noise emissions limites
- General zoning regulations
- Certified calibration

Mobile HRS

- CE and other certifications for subsystems utilized in HRS
- Permit according to „Betriebssicherheitsverordnung“
- CE and pressure vessel certifications for complete HRS
- Possibly further approvals:
 - Water protection
 - ATEX
 - Construction permit, if regularly used at one location

⇒ 3 to 6 months

Stationary HRS

- All of the above
- Normally more time required, since final certification possibly only after completion of construction and installation

⇒ 12 to 24 months

More stringent requirements if on-site hydrogen storage > 3t



Hydrogen Procurement

Possible supply methods:

- Pipeline connection
- On-site electrolysis
- Supply with trailers

Within the EU: De-facto requirement for use of RFNBO-certified hydrogen, since prerequisite for public subsidies

- ⇒ Hydrogen has to be generated through electrolysis, using renewable energy
- ⇒ Detailed requirements very complex and difficult to meet

Existing problems:

- Limited generation capacity
- Spread widely throughout Germany
- No standardized means of transport
- No standardized interfaces

- ⇒ Hydrogen supply should be secured before establishment of HRS





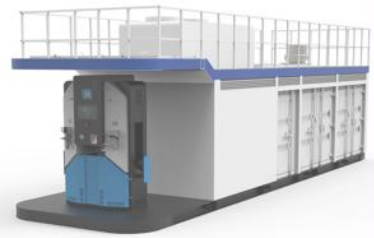
Earning Opportunities

- General demand for hydrogen for mobility still low
- Profitable operation of HRS normally requires long-term contract with anchor customer
 - Public transport companies
 - Logistics companies

Further earning possibilities:

- Sale of fuel to non-contracted vehicles
- In case of on-site electrolysis: Sale of fuel to other stations
- Service station:
 - Maintenance of H2 vehicles
 - Marketing of H2 vehicles





Public Funding & GHG Quotas

Currently ongoing funding program:

Paketförderung / Integrated Funding Package

- German Federal Ministry of Transport
- Implementation of EU AFIR Regulation
- Funding for hydrogen refueling stations in road transport in conjunction with commercial Vehicles with hydrogen-based propulsion systems
- In 78 metropolitan areas
- Along the highways of the TEN-V core networks
- maximum of seven million euros per package application
 - up to four million euros per hydrogen refueling station
 - Up to three million euros for vehicles

GHG Quotas

- Operators of HRS can generate and sell GHG certificates for green hydrogen sold



<https://webgate.ec.europa.eu/tentec-maps/web/public/screen/home>





Thank you very much for your attention!

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