


The background image shows a port scene with a teal overlay on the left side. The top part of the image shows industrial structures and cranes. The middle part shows a large body of water with a ship. The bottom part shows a ship's deck with various equipment and pipes.

# Commercializing Hydrogen Technology in the Ports

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CHBC Port workshop | October 10, 2018

A young child with short brown hair is dressed as a superhero. They are wearing a white tank top with a large red star on the chest, a red cape, and a red mask. The child has their arms raised in a flexing gesture, mimicking a superhero. The background is a clear blue sky. A semi-transparent white banner is overlaid across the middle of the image, containing the text.

**Must-haves** for commercial  
**success** of hydrogen  
technology in the ports

**Customer & Market**

*Individual Value*

**W**

**\$\$\$**

**Society**

*Public Value*

**?**

**Competitive  
Advantage**

**Infrastructure**

**Product**



# Customer & Market

## Value to the individual

- What are tangible benefits of hydrogen/  
zero-emission technology?
  - Clean - good citizen ...
- Meet regulatory requirements
- Advantage over competitors
- Emotional appeal ?!

local pollution

Public  
Value



climate change

Individual vs  
Public Value

Individual  
Value

Public  
Value



Individual vs  
Public Value



Individual Value

Public Value



business rationale

local pollution

good citizen

climate change

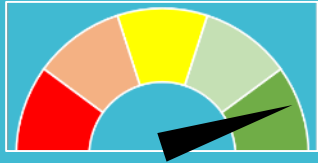


# Product

- Performance
  - Power
  - Range
  - Refill/recharge time
  - Weight
  - Fuel consumption
- Reliability and durability
  - Mean-Time-Between-Failures
  - Lifetime
- Safety
- Ease of operations
  - What operators are used to
  - No compromises
  - Simple







# Compe- titive Advan- tage




- Diesel vs H<sub>2</sub>
  - \$, reliability, ease of operations
  - environmental impact
- LNG vs H<sub>2</sub>
  - improvement over Diesel, easy transition
  - not zero-emission



- Battery-electric vs H<sub>2</sub>
  - fuel efficiency
  - range, recharge, weight

Tesla  
**Semi**

Semi is the safest, most comfortable truck ever. Four independent motors provide maximum power and acceleration and require the lowest energy cost per mile.

 <b>20<sub>s</sub></b> 0-60 mph with 80k lbs	 <b>&lt; 2 kWh/mi</b> Energy consumption	 <b>0.36<sub>C<sub>d</sub></sub></b> Drag Coefficient	<a href="#">Reserve now</a>
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# Battery vs hydrogen tank



	Tesla	Fuel Cell	Diesel
range	500 miles		
specific energy consumption		2 kWh/mile	0.56 ltr Diesel/mile
total energy consumption		1,000 kWh	280 ltr
energy storage	1,000 kWh battery	60 kg H <sub>2</sub>	280 ltr Diesel
storage weight	5,000 kg	1,667 kg	280 kg

**Reduced payload!**

# Battery recharging vs hydrogen refueling

	charge power [kW]	charge time	
		[hr]	[min]
Battery capacity 1000 kWh	1000	1	60
Level 3 charger	7.5	133	8000
Fast charger	50	20.0	1200
Tesla Supercharger	120	8.3	500
Porsche Fastcharger	350	2.9	171
1.5 MW charger	1500	0.67	40
Hydrogen refueling time	n/a	0.5	25



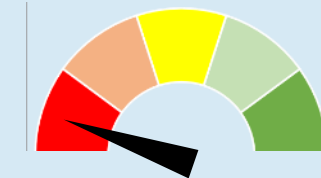
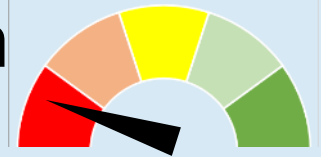
How much is

1.5 MW ?



## Infra- structure

- Hydrogen production
- Hydrogen station
- Distribution of hydrogen to the users
- Sector and application coupling



# Hydrogen

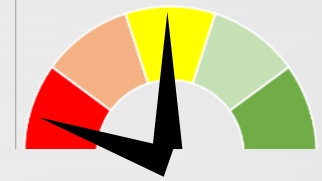
100%

\$\$\$

## Profitable for customer AND manufacturer

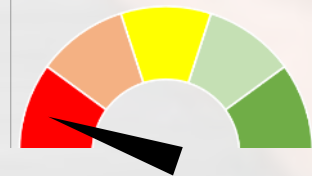
- Customer perspective

- Purchase price
- Total cost of ownership
  - purchase price
  - fuel
  - maintenance
  - insurance



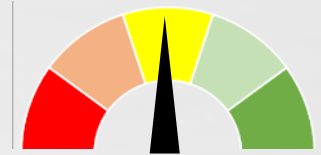
- Manufacturer perspective

- Sufficient (positive !) margin

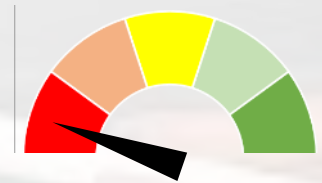


# PROFITABILITY

- Policy framework
  - Subsidies
  - Compliance cost
  - Credits



- Infrastructure business case
  - H2 stations as a profitable business



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Margin

Costs

A yellow chick is sitting on a large orange egg. The chick is positioned in the upper half of the frame, and the egg is in the lower half. A red-bordered box is overlaid on the image, containing text.

There is no chicken-and-egg problem:

Infrastructure investments are financially attractive and will happen - if enough vehicles and other hydrogen applications are around !



**Customer & Market**

**CRITICAL**

*Individual Value*

**Society**

**GOOD**

*Public Value*

policy framework !

**CRITICAL**

\$\$\$

cost reduction  
infrastructure business case

**GOOD**

**Competitive  
Advantage**

over other ZE technologies

**CRITICAL**

**Infrastructure**

distribution to users  
application coupling

**OK!**

**Product**

lifetime  
ease of operations



We are on a good path  
**BUT**  
Demos are not enough !



Thank you!

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