ELEKTRA

Development and Realisation of the world's first emission free push boat for commerical use on inland waterways

EBMS TU berlin

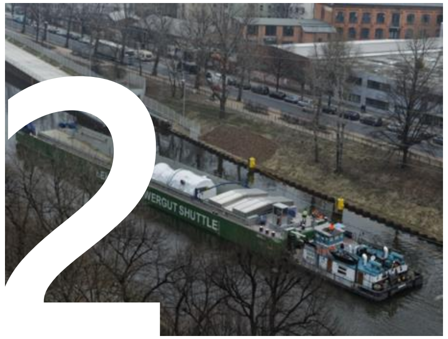
Gefördert durch:
Bundesministerium für Digitales und Verkehr
aufgrund eines Beschlusses des Deutschen Bundestages

Koordiniert durch:
NOW nip
Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie
PtJ Projektträger Jülich Forschungszentrum Jülich

05. Mai 2022 | InterGreen-Nodes | Jan Spereiter, M.Sc.

AGENDA

MOTIVATION & A BRIEF LOOK ON HISTORY



REQUIREMENTS & CONSTRAINTS - DESIGN CASE

SHIP- AND ENERGY-LAYOUT OF THE ELEKTRA

ENERGY SUPPLY INFRASTRUCTURE

SUMMARY

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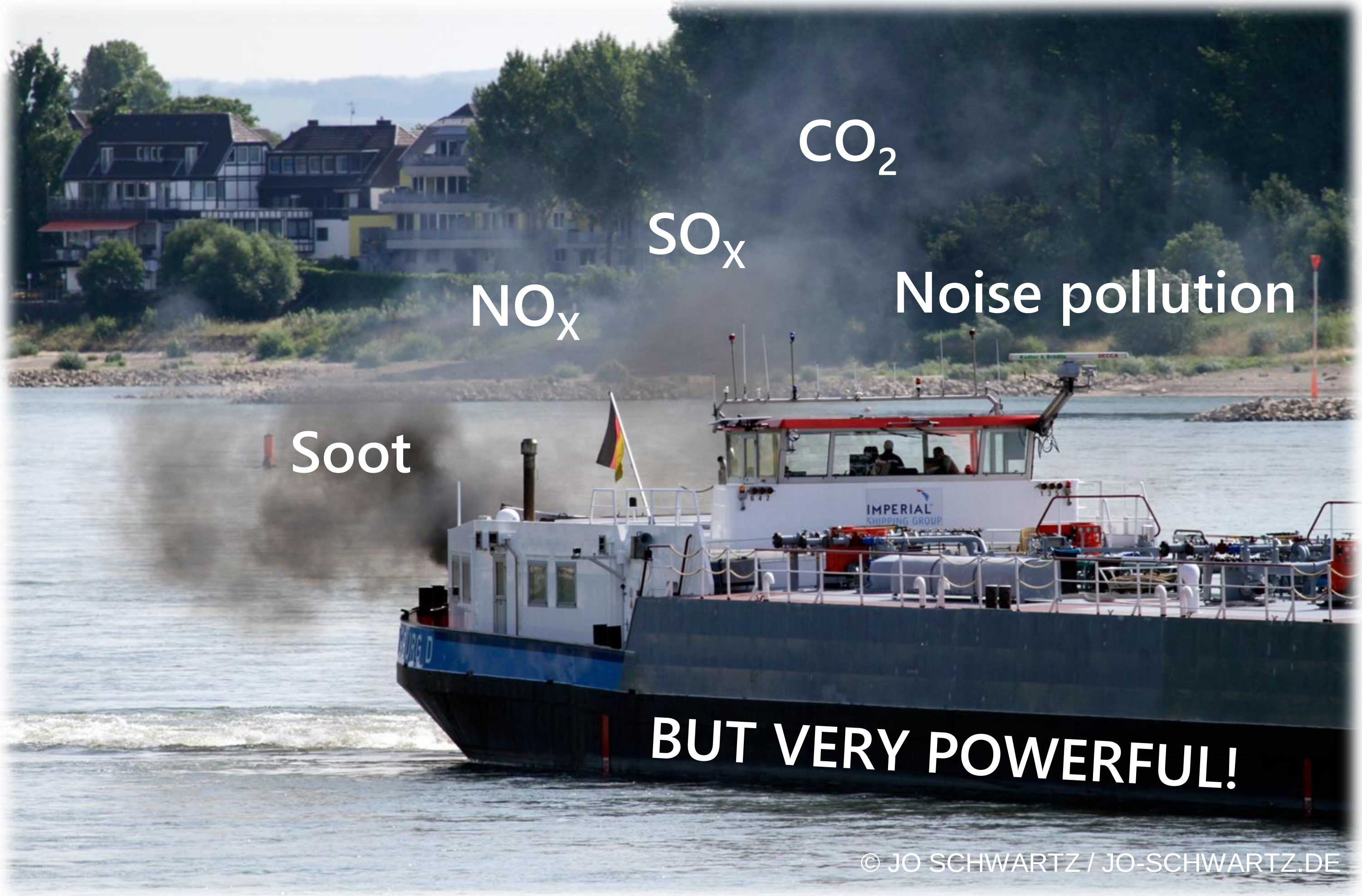
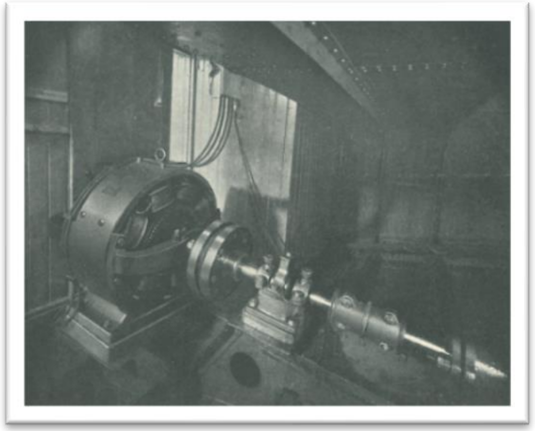
MOTIVATION

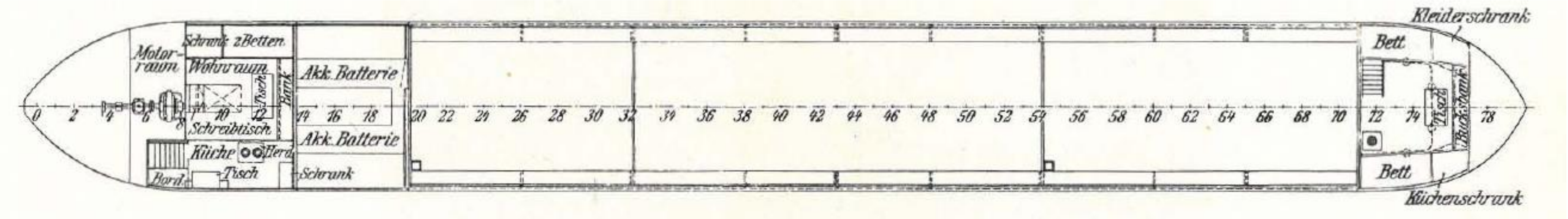


CO_2
SO_X
NO_X
Noise pollution
Soot
BUT VERY POWERFUL!
© JO SCHWARTZ / JO-SCHWARTZ.DE

HISTORY OF EMISSIONFREE SHIPPING AT BERLIN

Purpose:	brick transport from Zehdenick *(north of Berlin) to* Berlin
Key-Facts:	*„Finow-Maßkahn“,* 40,0 x 4,6 x 1,3 m, 150 dwt
Propulsion:	DC 7 kW
Battery weight:	9,5 t (lead battery, 6%! of dwt)
Range:	90 km
Quantity:	approx. 120 ships in commercial use (1908)

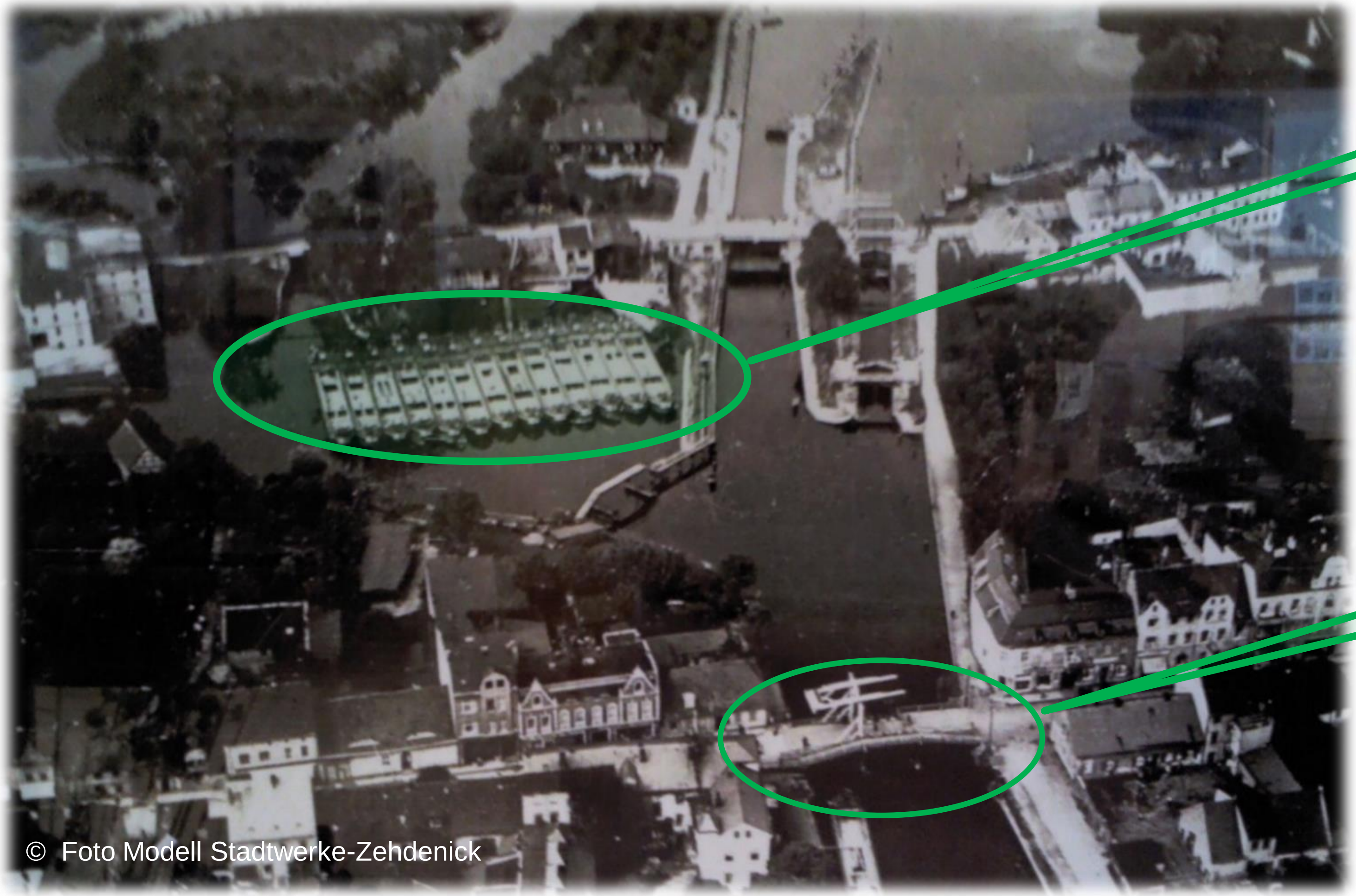




Source: Jahrbuch der Schiffbautechnischen Gesellschaft 1908

HISTORY OF EMISSIONFREE SHIPPING AT BERLIN

Charging point at Zehdenick around 1910



Brick barges

Regenerative power generation through barrages

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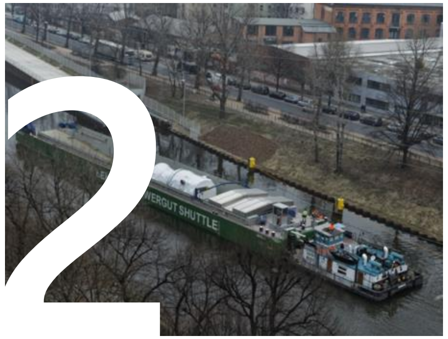

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REQIREMENTS & CONSTRAINTS – DESIGN CASE

The main task of „ELEKTRA“ in conjunction with „URSUS“:

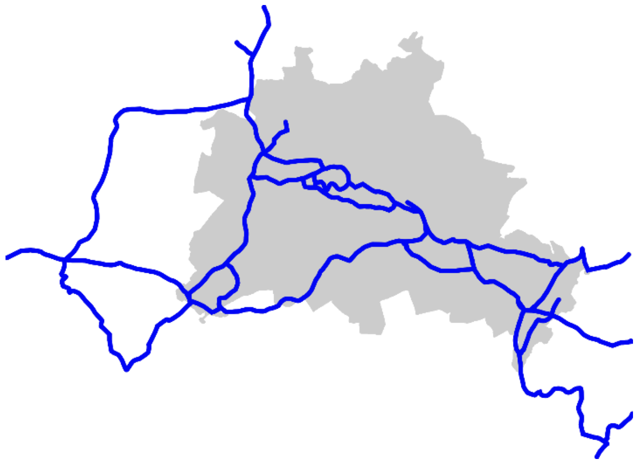
- RoRo – project loads
- regional / supra-regional transport of heavy duty goods, e.g. gas turbines from the Siemens AG / Berlin plant

Heavy Cargo RoRo-Barge „URSUS“
Length 64.50 m | Width 9.50 m
Displacement 1,400 t | Draught 1.30 m – 3.06 m

Loading ramp
length 265 m

REQIREMENTS & CONSTRAINTS – DESIGN CASE

REGIONAL OPERATION



- Berlin area
- Approx. range of 65 km / day (8h)
- Service speed: 8 km/h, up to 10 km/h
- Drive: primarily battery-electric

- Berlin ↔ Hamburg
- Operating area: Zone 3+4 (without Rhine)
- Approx. range of 130 km / day (16h)
- Average service speed: 8.5 km/h
- Drive: hybrid-electric (FC/batteries)

SUPRA-REGIONAL OPERATION

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SHIP LAYOUT

Main dimensions

- Length: 20.00 m
- Width: 8.25 m
- Draught: 1.28 m
- Displacement: approx. 130 t

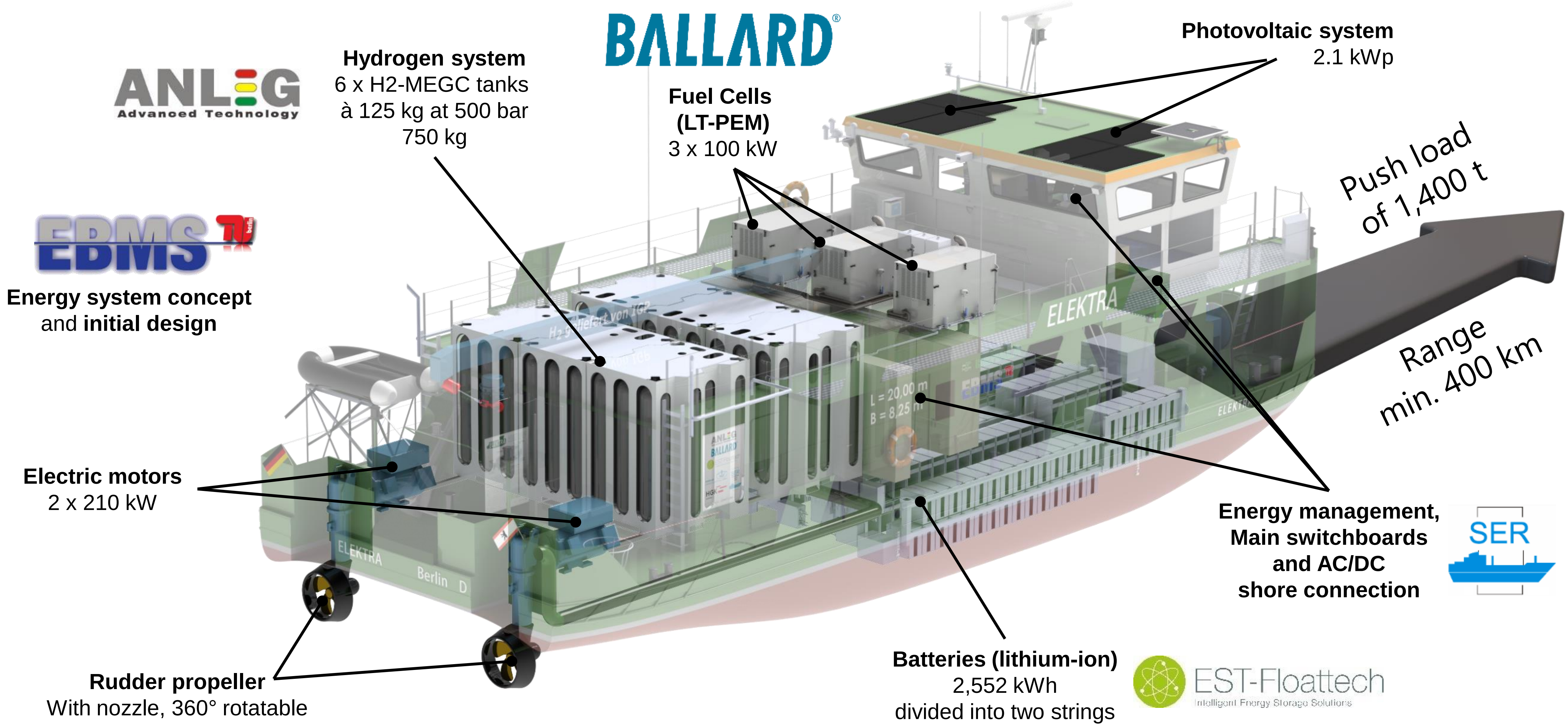
Operational range

- Total range with 1,400 t push load approx. 400 km
- Battery-electric: 8 h / 65 km / day
- Hybrid-electric: 16 h / 130 km / day

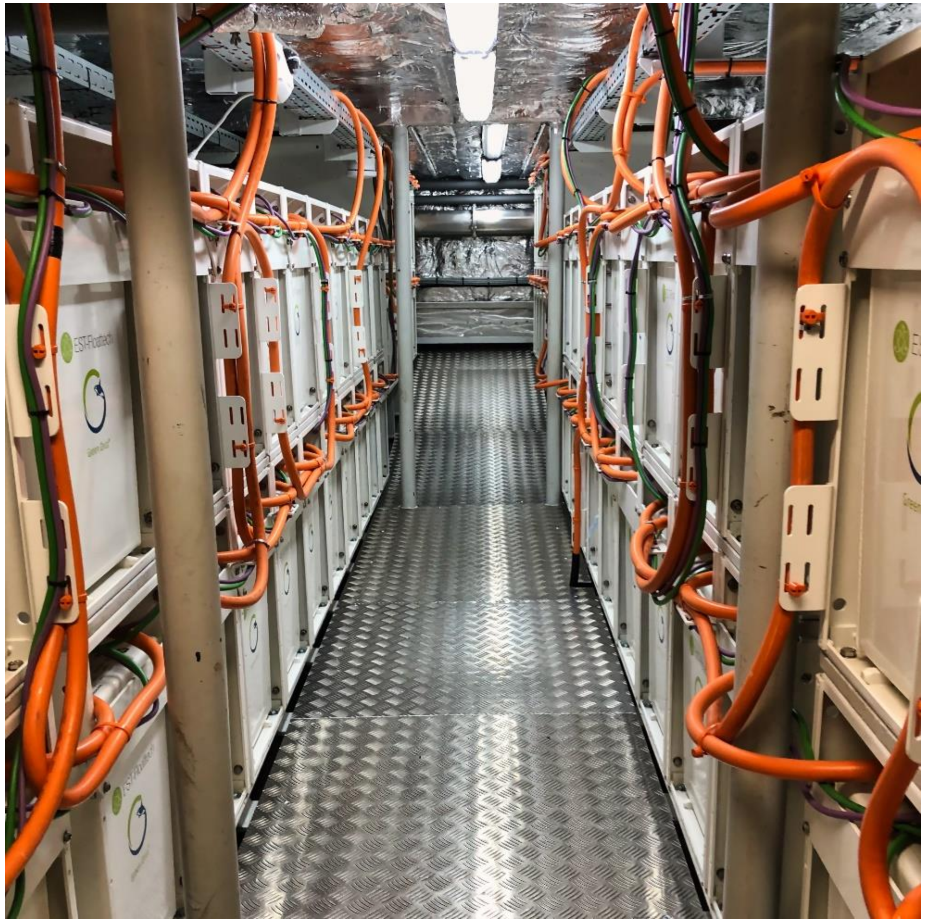
Propulsion

- Water-cooled electric motors: 2 x 210 kW
- Rudder propeller

ENERGY SYSTEM LAYOUT



ENERGY SYSTEM LAYOUT – BATTERY SYSTEM

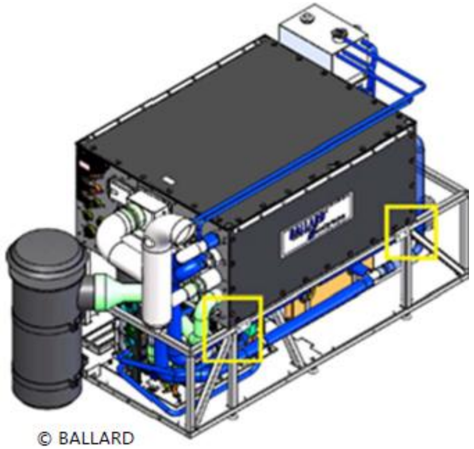


EST-Floattech
Intelligent Energy Storage Solutions

- **cell chemistry:** NMC (nickel manganese cobalt oxide)
- **total capacity:**
  - 2,552 kWh (installed) (~ 2,160 kWh usable)
  - approximately 1,800 kWh @EOL (theoretically ~15-20 years)
- **total system weight:** approx. 25 tonnes (15 % of the ELEKTRA overall weight)
- incl. **temperature management** and **integrated fire protection system**
- no active fire protection in the room
- **fully charged** via shore connection in 7 to 8 hours (SER)

SER

ENERGY SYSTEM LAYOUT – FUEL CELL SYSTEM

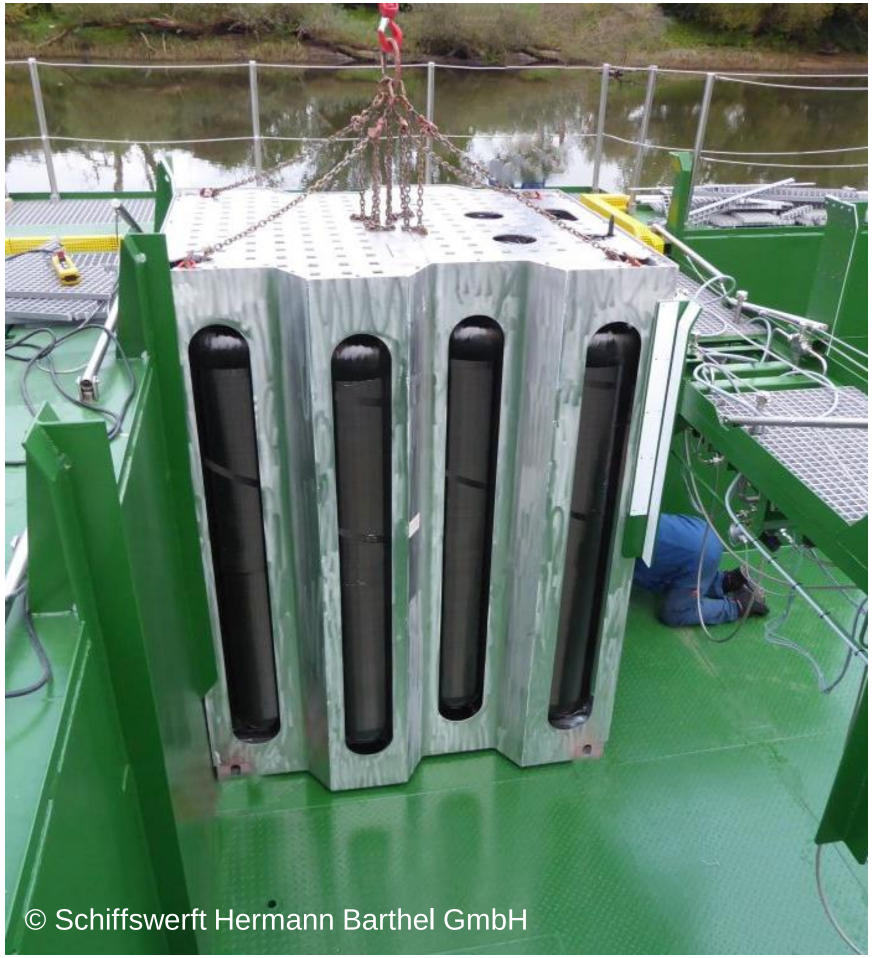


FCveloCity®-HD 100

BALLARD®

- **LT-PEM-FC** incl. cooling (water) and compression system
- **3 x 100 kW** units installed on board
- **Individually independent operation** possible per FC
- Goal: small load operating window ~ stationary operating behavior - approx. **200 kW base load**
  ~16 h continuous operation window
- Frost-proof
- Remote diagnostic capability
- Integrated H_2-sensor monitoring
- Service life up to 15 years, then refit if necessary

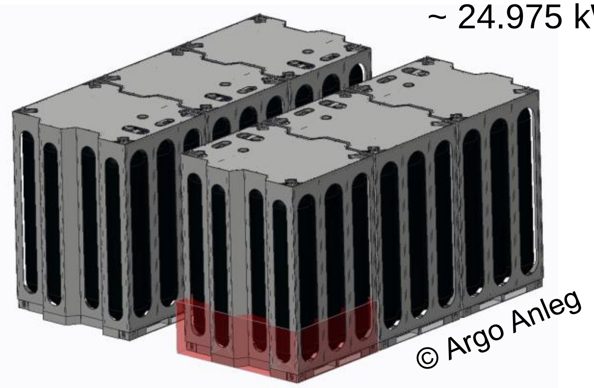
ENERGY SYSTEM LAYOUT – HYDROGEN STORAGE SYSTEM



ANLEG

- MEGCs (Multiple-Element Gas Containers)
- Type IV (carbon) high pressure cylinders, GH_2 500 bar
- 6 modules on board, 6 in circulation
- individually craneable and fork-lift truck capable
- Transport by truck trailer or rail
- Total mass: approx. 18 t
- 750 kg GH_2 usable on board

750 kg hydrogen
~ 24.975 kWh

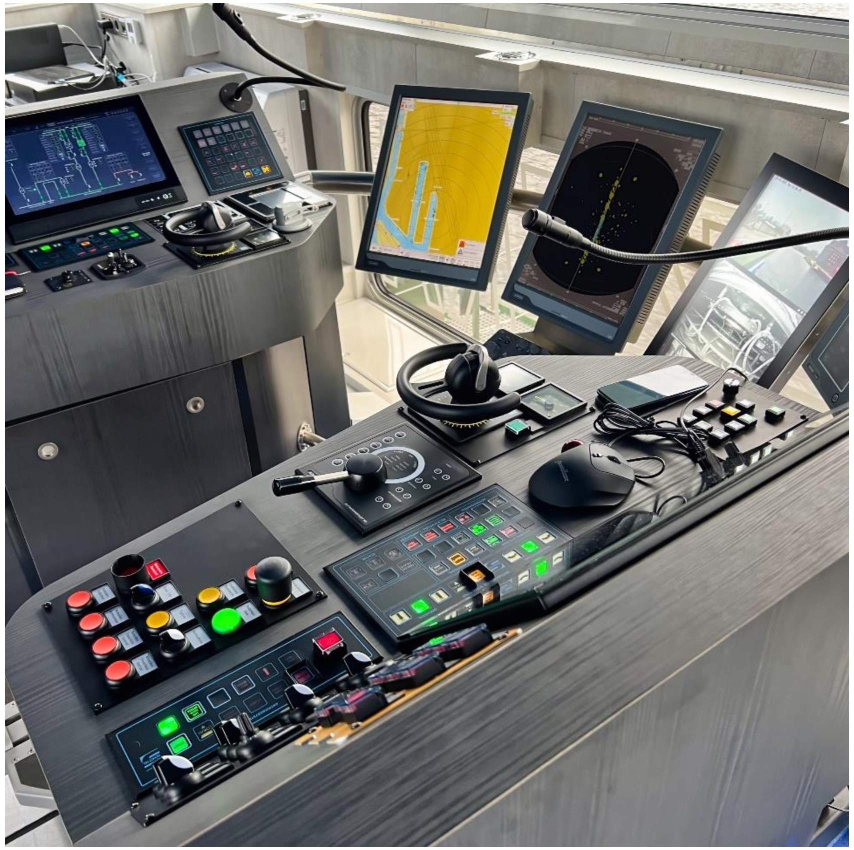


2.550 l Diesel ~ 24.990 kWh

The „hydrogen dilemma“

- Energy content of hydrogen: 33.3 kWh/kg
- Energy content of diesel: 11.95 kWh/kg
- Density of gaseous hydrogen at a pressure of 500 bar: 0.031 kg/l
- Density of diesel: 0.82 kg/l

ENERGY SYSTEM LAYOUT – ENERGY MANAGEMENT SYSTEM



SER

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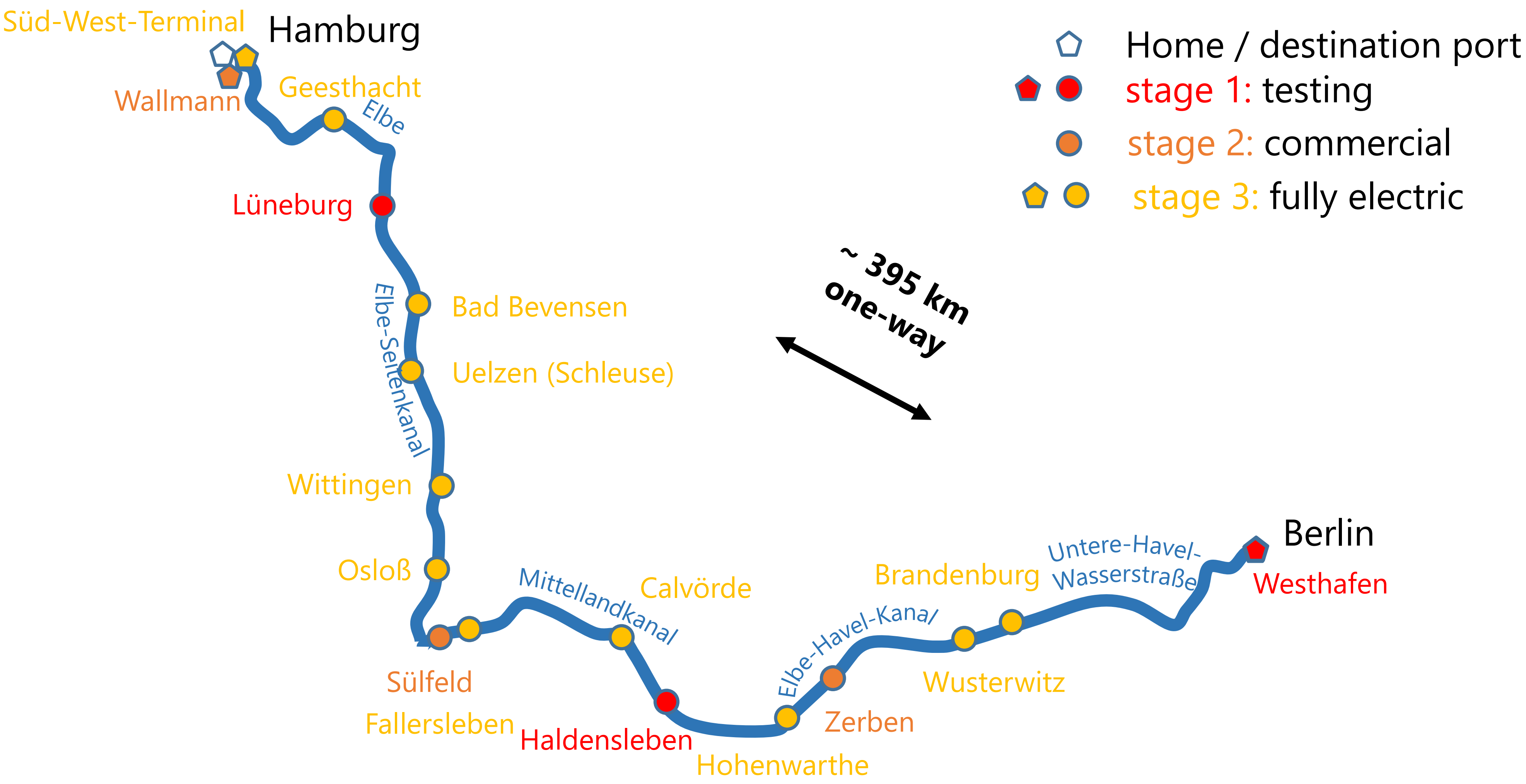
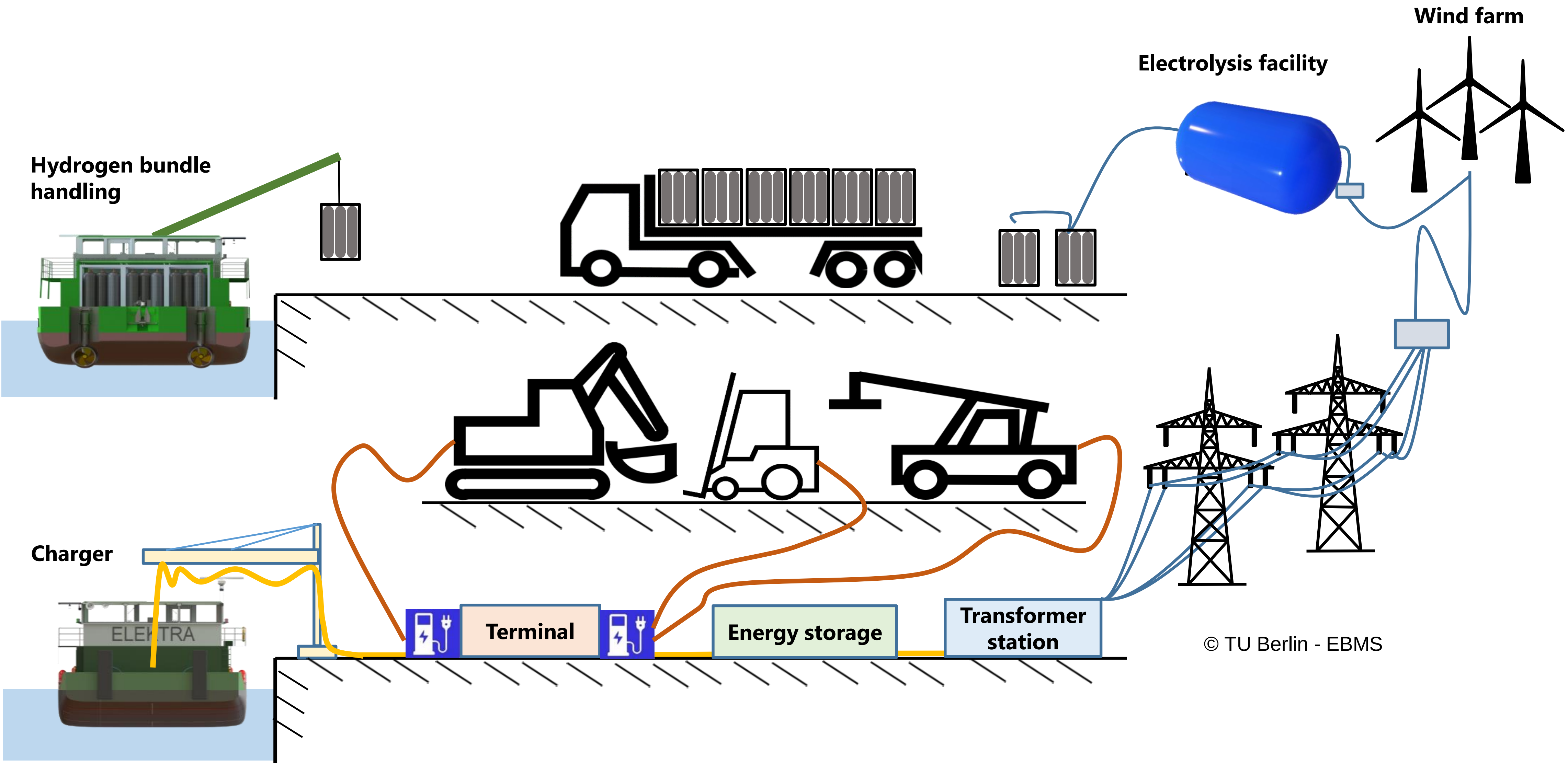
ENERGY SUPPLY INFRASTRUCTURE – CURRENT SITUATION

- **Shore power** connections with **16 A CEE** plugs are **currently available** at some berths -> primarily used to **supply the on-board power supply**
- **Medium-term expansion** of electrification of waterways **up to 32 A CEE system** -> ensure shore-side on-board power supply and avoid operation of ship's engines to generate electricity in port, **still not sufficient for charging**!
- Transmission of larger amounts of energy for storage in short periods of time, as is the case with electric vehicles, is **not covered by the described infrastructure. 63 A CEE** would be **sufficiend, 125 A CEE even better** (both possible with the ELEKTRA AC-/DC shore connection).
- **PowerLock system** for the supply of river cruise ships for emission-free mooring times established -> Handling, however, is **very material- and labour-intensive**
- **Freight shipping** -> crew manpower should not be tied up unnecessarily for connecting the shore loading infrastructure, taking into account working time laws

ENERGY SUPPLY INFRASTRUCTURE – ELEKTRA DESIGN CASE



CONCEPT FOR HYDROGEN AND ELECTRICITY SUPPLY



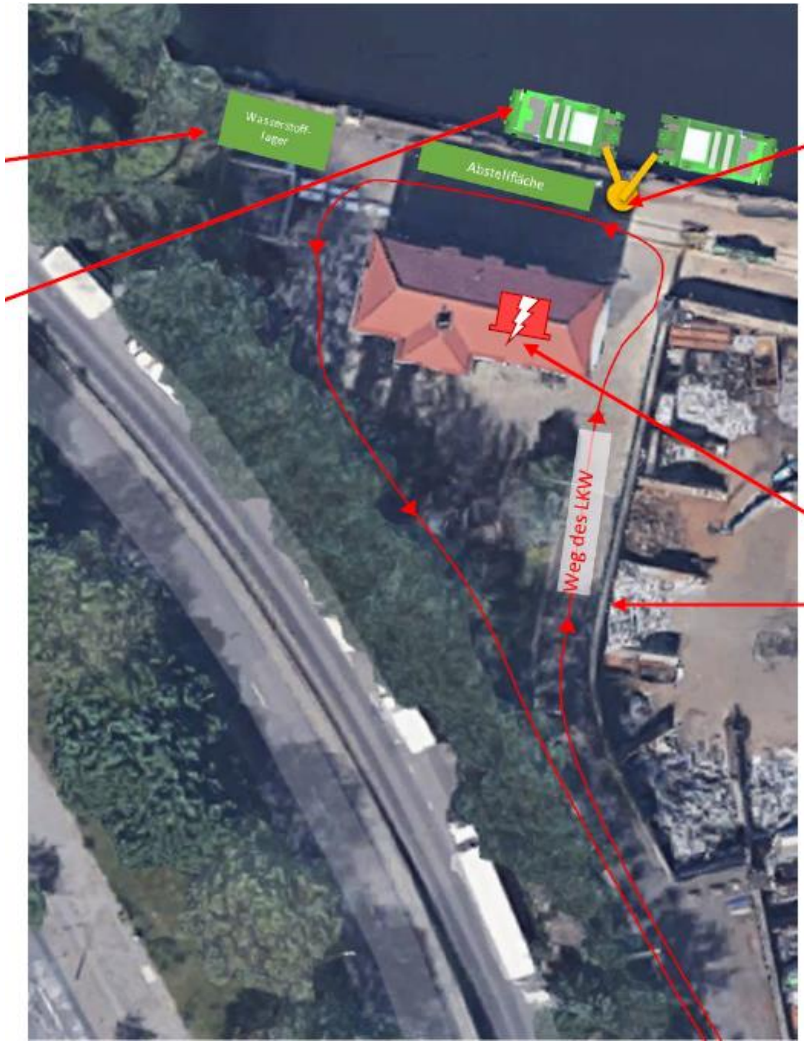
CONCEPT FOR HYDROGEN AND ELECTRICITY SUPPLY - WESTHAFEN

Hydrogen storage,

approx.750 kg at 500 bar in

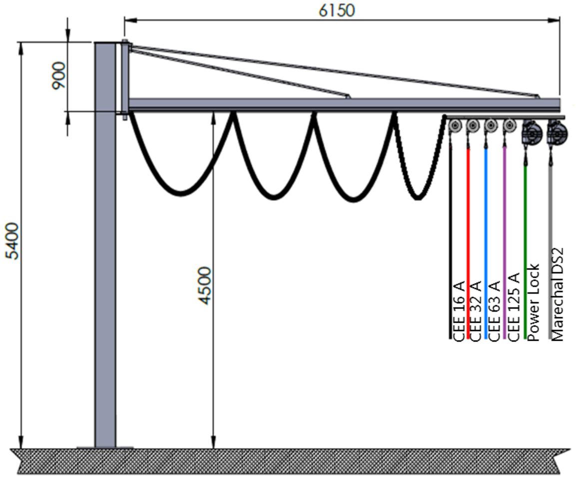
6 tank systems

Vessels to be supplied



Transfer boom for Power cables

- Powerlock (400 V_{AC})
- Marechal DS2 (700 V_{DC})
- CEE (400 V_{AC} 1 x 125/63/32/16 A each)



Transformer Station (400 V, 630 kVA)

Traffic routes for trucks

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I. **Local and global low-emission** (= CO_2 and pollution-free) waterborne transport in metropolitan regions and supra-regional **is feasible today** (**zero-emission transport**, locally and globally, achieved through the futher use of green hydrogen and green electrical power).

II. Further **development of** the **charging and H_2-infrastructure** is **necessary.**

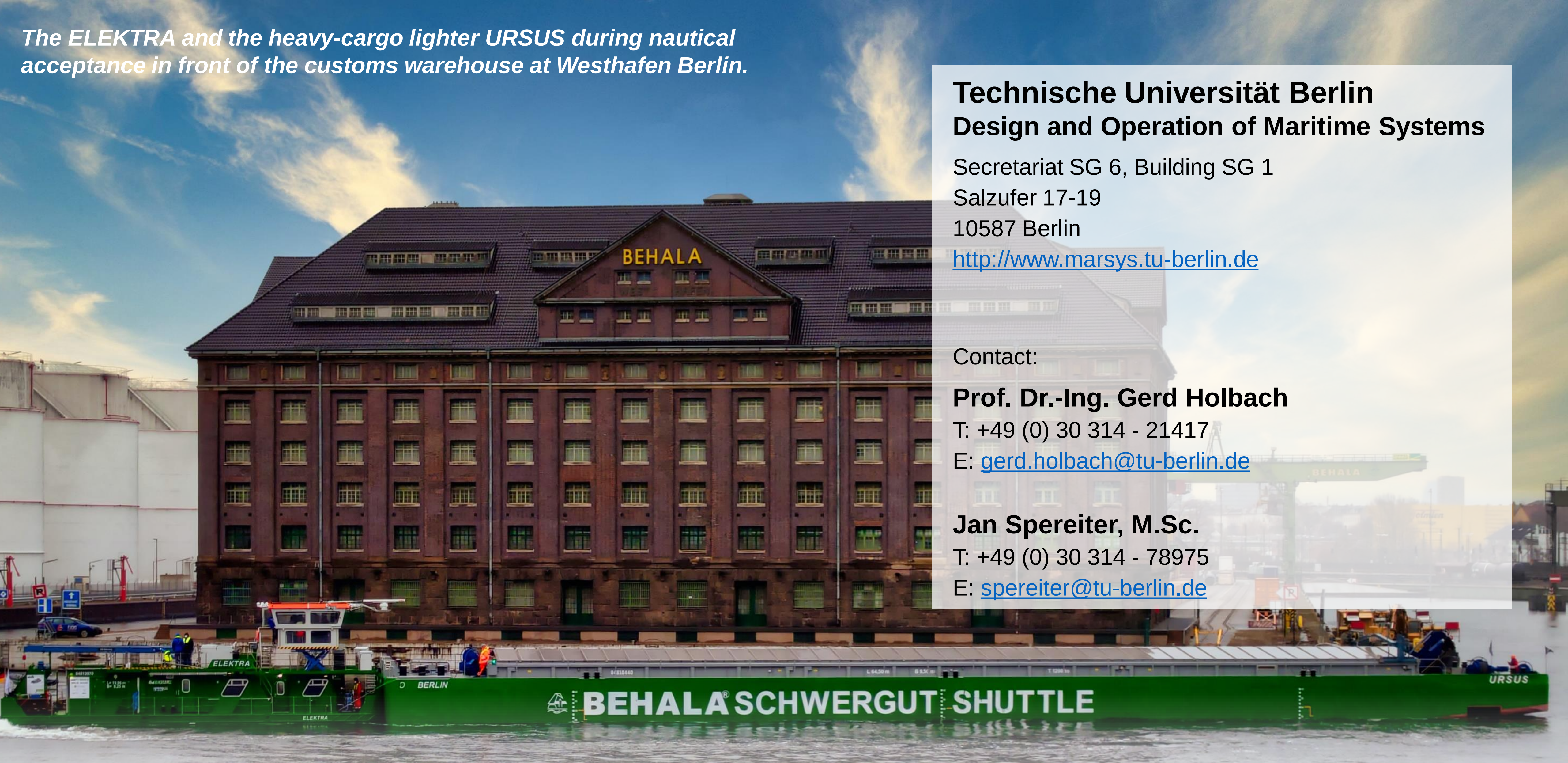
III. **Cost** for green hydrogen and green electricity **must come down.**

IV. **Efficient inland waterway vessels** with H_2 fuel cells and battery energy storage systems **are feasible.**

V. **Rules and Regulations** enabling economic use of the technology **need to be created** and are **necessary** for reliable **investments** today.

VI. The energy system of the ELEKTRA is a **blueprint for inland and coastal shipping.**

The ELEKTRA and the heavy-cargo lighter URSUS during nautical acceptance in front of the customs warehouse at Westhafen Berlin.



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EBMS BEHALA SER HGK SHIPPING Schiffswerft HERMANN BARTHEL GMBH EST-Floattech Intelligent Energy Storage Solutions ANLEG Advanced Technology BALLARD