# Approach to data collection of the Inland Waterways

## Activities and experiences in the IWT sector


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MITGLIED DER Johannes-Rau-Forschungsgemeinschaft

# Fields of Activity at DST

- Shallow water hydrodynamics
  - Inland vessels,
  - Coaster
  - Seagoing vessels
- Design and construction of inland vessels
- Alternative energy carriers and propulsion systems
- Transportation systems und logistics
- Education (in navigation)
- Flow and wave energy systems

# Introduction

Mannheim Declaration from 2018:
“[…] to develop a roadmap in order to

- reduce greenhouse gas emissions by 35% compared with 2015 by 2035,
- reduce pollutant emissions by at least 35% compared with 2015 by 2035,
- largely eliminate greenhouse gases and other pollutants by 2050. […]”

IMO-GHG Strategy from 2018:

“[…] reduction in carbon intensity of international shipping (to reduce $CO_2$ emissions per transport work), as an average across international shipping, “

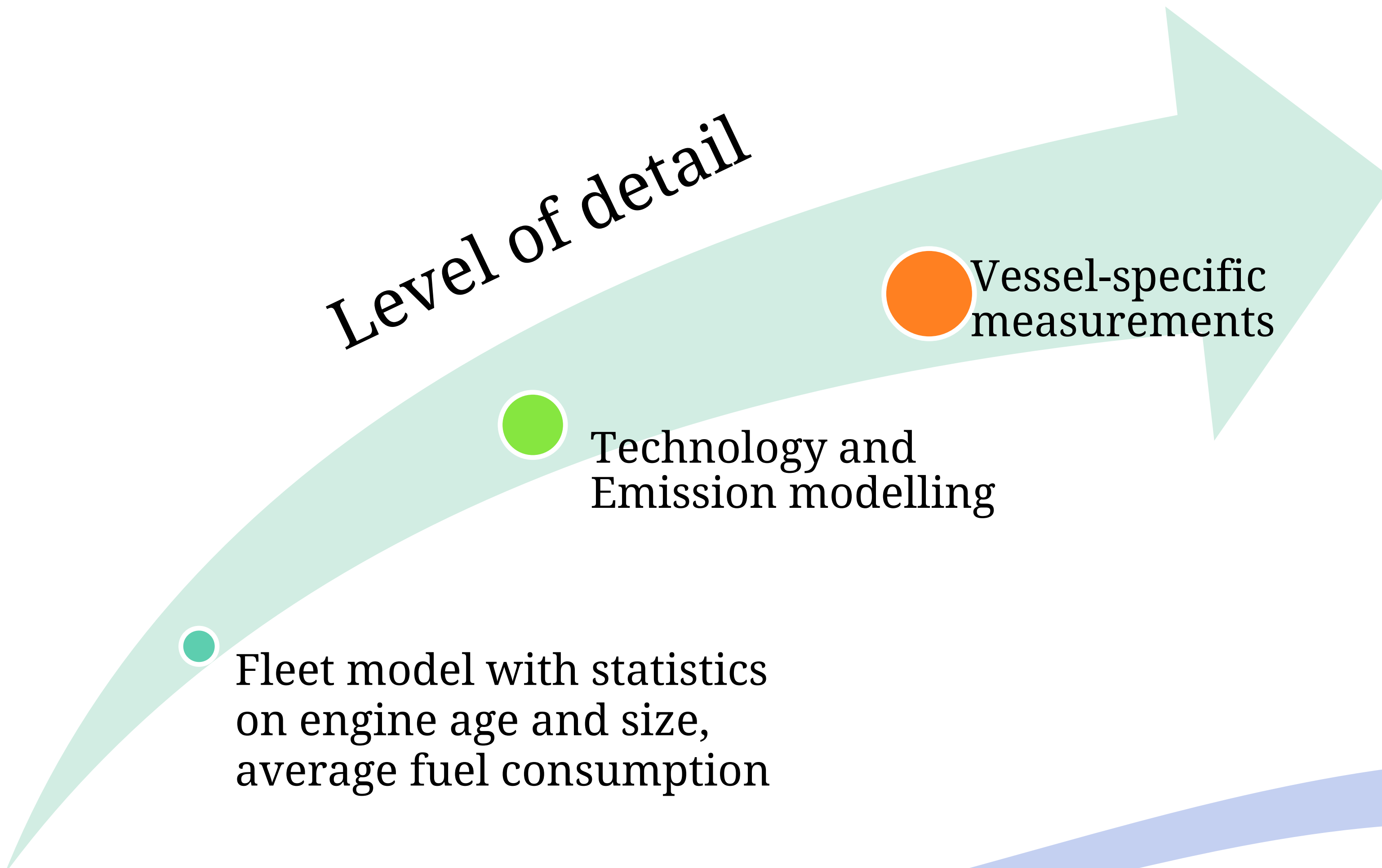
- by at least 40% by 2030,
- pursuing efforts towards 70% by 2050, compared to 2008
- low sulphur, since 2020 0.5% outside SECA and 0.1% insinde

# Introduction

What are the options?

| | | | | |
|---|---|---|---|---|
| Battery, Fuel Cell<br>(ideal upstream chain) | ~~$CO_{2,\ global}$~~ | ~~$CO_{2,\ local}$~~ | ~~$NO_x$~~ | ~~PM~~ |
| Bio-Fuels, E-Fuels<br>(exhaust after treatment) | ~~$CO_{2,\ global}$~~ | $CO_{2,\ local}$ | $NO_x$ | PM |
| Stage V, LNG<br>(Bio Blend) | $CO_{2,\ global}$ | $CO_{2,\ local}$ | $NO_x$ | PM |

# Data collection



# PROMINENT project

- H2020, GA 633929, 05-2015 to 04-2018
- Promoting Innovation in the Inland Waterways Transport Sector
- Fleet statistics from databases

## *D1.1 List of operational profiles and fleet families*

*Identification of the fleet, typical fleet families & operational profiles on European inland waterways*

| | Unregulated (before 2003) | CCNR stage 1 engine (2003-2007) | CCNR stage 2 engine (>2007) |
|---|---|---|---|
| Passenger vessels | 70% | 12% | 18% |
| Other push boats <500 kW | 87% | 7% | 6% |
| Push boats 500-2000 kW | 53% | 29% | 18% |
| Push boats >=2000 kW | 36% | 27% | 36% |
| Motor vessels dry cargo >=110m | 13% | 52% | 34% |
| Motor vessels liquid cargo >=110m | 11% | 32% | 57% |
| Motor vessels dry cargo 80-109m | 73% | 18% | 9% |
| Motor vessels liquid cargo 80-109m | 44% | 19% | 37% |
| Motor vessels <80m | 77% | 16% | 7% |
| Coupled convoys | 12% | 42% | 45% |

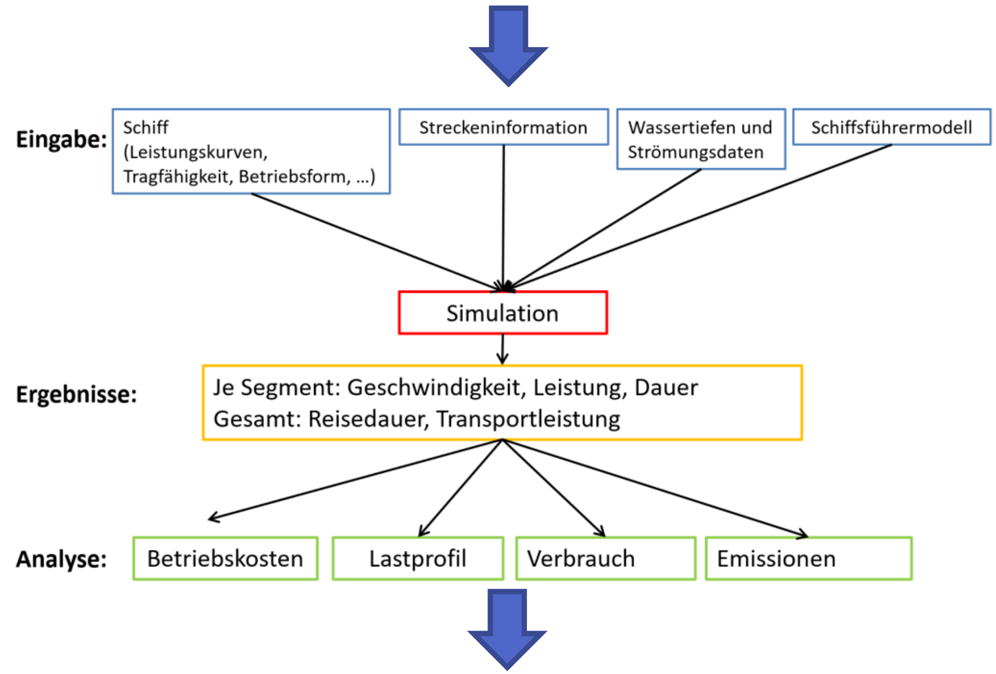
| Fleet families | Fleet 2015 | Fuel consumption per FF [t] | Average fuel consumption per year per Ship (in m³) | Average fuel consumption per year per Ship (in t) | kWh/Year per FF | Unregulated engine (before 2003) | CCNR stage 1 engine | CCNR stage 2 engine |
|---|---|---|---|---|---|---|---|---|
| Passenger vessels (large hotel) | 346 | 143.590 | 500 | 415 | 652.681.818 | 1% | 14% | 85% |
| Push boats <500 kW | 890 | 28.480 | 32 | 27 | 107.447.273 | 87% | 7% | 6% |
| Push boats 500-2000 kW | 520 | 82.160 | 158 | 131 | 309.967.273 | 53% | 29% | 18% |
| Push boats ≥2000 kW | 36 | 74.520 | 2.070 | 1.718 | 281.143.636 | 36% | 27% | 36% |
| Motorvessel dry cargo ≥110 m | 610 | 206.790 | 339 | 281 | 780.162.273 | 13% | 52% | 34% |
| Motorvessel liquid cargo ≥110 m | 602 | 206.486 | 343 | 285 | 779.015.364 | 11% | 32% | 57% |
| Motorvessel dry cargo 80-109 m | 1.802 | 291.924 | 162 | 134 | 1.101.349.636 | 73% | 18% | 9% |
| Motorvessel liquid cargo 80-109 m | 647 | 153.339 | 237 | 197 | 578.506.227 | 44% | 19% | 37% |
| Motorvessels <80 m | 4.463 | 218.687 | 49 | 41 | 825.046.409 | 77% | 16% | 7% |
| Coupled convoys | 140 | 78.120 | 558 | 463 | 294.725.455 | 12% | 42% | 45% |
| Ferries | 103 | 10.187 | 99 | 82 | 38.431.980 | 77% | 16% | 7% |
| Day trip and small hotel vessel | 2.207 | 119.178 | 54 | 45 | 449.626.091 | 77% | 16% | 7% |

# PROMINENT (T1.1)

- Task of the DST: Determination of the operational profiles for the voyages.
- Approach: Voyage simulation in (if available) temporally and spatially resolved environmental conditions (data for the Rhine provided by BfG, later locally higher resolution models by BAW).
- Challenge: Data acquisition and skipper model

**→ What would this look like for a tug?**

| | Selected representative journeys Rhine / ARA | | | | | | | Vessel dimensions (m) | |
|---|---|---|---|---|---|---|---|---|---|
| | Port A | Port B | Type | Vessel type | CEMT Class | Commodity | mln tkm | Length | Width |
| 1 | Rotterdam | Duisburg | Dry bulk | Push B4 | VI | Ore | 4074 | 195 | 22.8 |
| 2 | Rotterdam | Antwerp | Container | C3L/B | VI | Containers | 3067 | 108,5 + 73,5 | 11.4 |
| 3 | Rotterdam | Karlsruhe | Liquid Bulk | MTS 135m | V | Crude oil | 2478 | 135 | 11.45 |



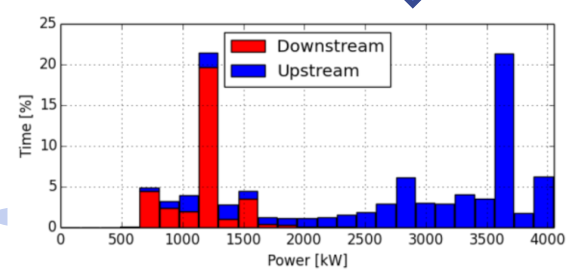




Figure 24: Operational Profile for Journey 01 (Pushed Convoy, Rotterdam - Duisburg, Ore)

# CCNR Studies

**Research Question C**

Which greening techniques fit into zero-emission development of IWT and what are the impacts?

- Analysis of the initial situation
- Introduction of energy carriers
- Description of technologies
- Compilation of cost (projections)
- Creation of the baseline scenario (BAU)
- Development of scenarios to achieve the goals
- Quantification of CAPEX, OPEX and TCO

Link to CCNR page on Financing the energy transition
DST-Study Edition 1
DST-Study Edition 2 (together with EICB)

# Fact sheets on technolgies

Technology Assessment

- Gas and Gas-Electric
- Diesel-Electric
- Aftertreatment
- Fuel Cells
- Battery-Electric
- Drop-In (bio) Fuels
- EuroVI and NRE
- Energy Efficient Navigation
- ....

https://www.dst-org.de/en/grendel-3/

This fact sheet offers insight into various applications of fuel cells for propulsion and auxiliary power in inland ships. Hydrogen storage options and alternative energy carriers are presented with their pros and cons in brief. Information ranges from relevant regulations, technical concepts including benefits and downsides to recommendations for further reading.

**FACT SHEET N° 4**

**FUEL CELL PROPULSION**


**FACT SHEET**
**FUEL CELL**

## REGULATIONS

The **European committee for drawing up common standards in the field of inland navigation (CESNI)** does not consider the installation of fuel cells in its current regulation **for European Standard laying down Technical Requirements for Inland Navigation vessels (ES-TRIN - 2019/1).**

The **ES-TRIN** requires that all electrical installations on board must be designed for a constant inclination of 15°. In addition, the energy supply must in principle consist of at least two energy sources. If one energy source fails, the remaining energy source must be able to provide the required energy for at least 30 minutes. This means that either the fuel cells have to be divided into (at least) two systems including the fueling system or a battery with sufficient capacity needs to be implemented.

**Classification societies** like DNV GL have already guidelines for the installation of fuel cells since 2016. The predecessor Germanischer Lloyd has had regulations for the use of fuel cells since 2002 and they were the first classification society to think about this topic.

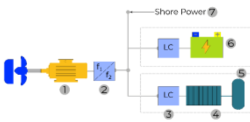
## FUEL CELL FACTS

Fuel cells are energy converters that continuously convert the chemical energy of the fuel, such as hydrogen, natural gas or methanol, into electrical energy and thermal energy (heat losses) using an oxidant such as oxygen. The fuel cell can supply electricity as long as suitable fuel is available.

The principle of the fuel cell was invented in 1838, however the first commercial use of fuel cells came more than a century later in NASA space programs to generate power for satellites and space capsules. Since then, the improvement of the fuel cell began and nowadays they are used in many other applications, e. g. for primary and backup power for commercial, industrial and residential buildings and in remote or inaccessible areas. The second most important application for fuel cells is as a power source for vehicles of all kinds.

With fuel cells local emission-free power generation is possible. The comparison of a fuel cell with a conventional internal combustion engine shows that no mechanical stress on components takes place because no fuel is burned. This results in no wear, vibration or generation of noise.

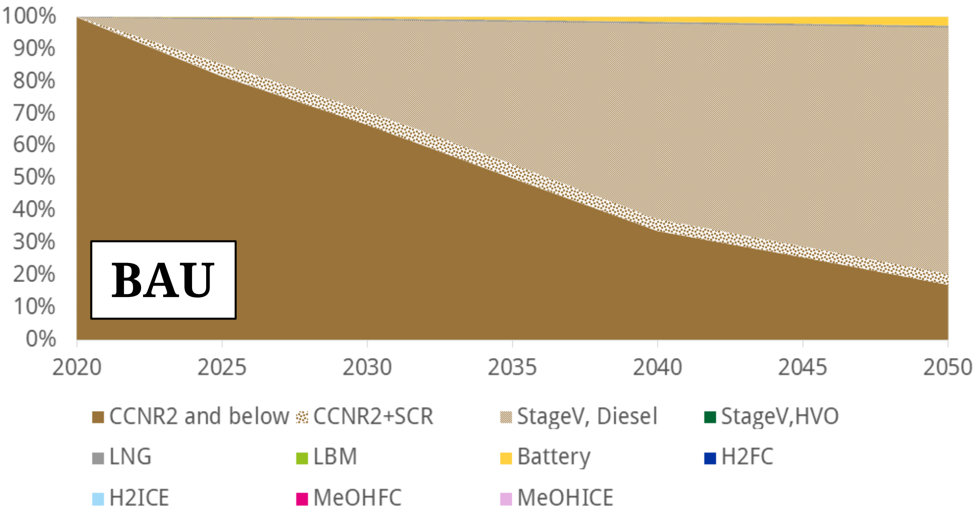
## TECHNICAL CONCEPT

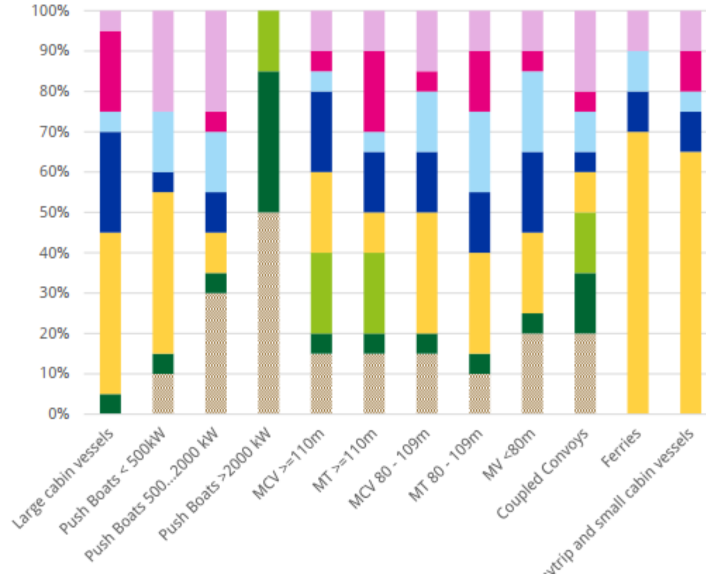


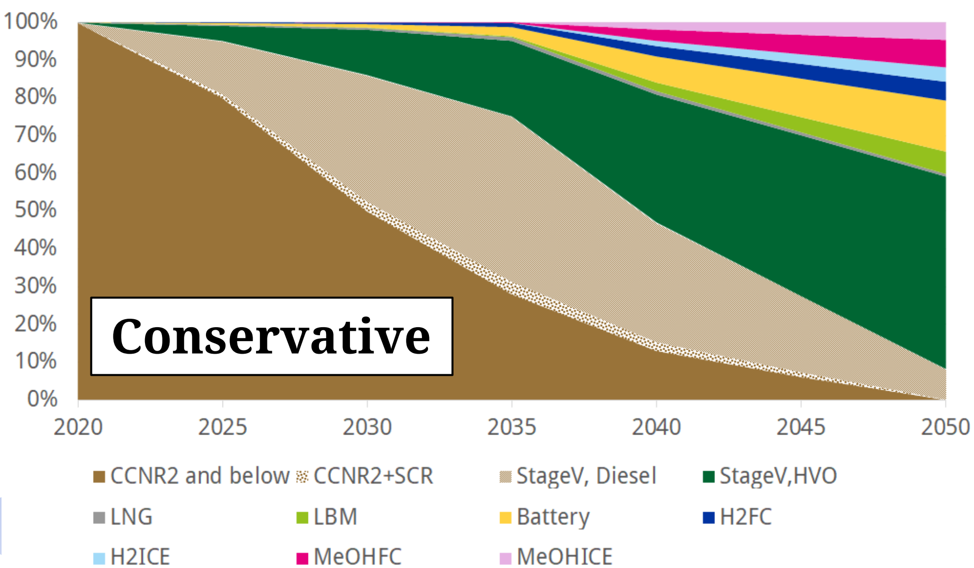

The electric motor (1) drives the propeller with constant rpm at any load case. Its advantage is a nearly constant efficiency at all load cases. Depending on the selected electric motor a gear box can be omitted. The frequency converter (2) supplies the electric motor with a frequency and voltage amplitude variable AC voltage. The converter can be supplied by any AC or DC on board energy grid. The rotational speed of the electric motor is controlled by varying the output frequency. The main switch board (3) distributes the energy from all sources to all loads. The loads are frequency converters at the propulsion system. The fuel cell (4) provides the base load. The fuel is sored in the tank (5). Peak loads are absorbed by the battery (6) which can be charged either by the fuel cell or via shore power (7).

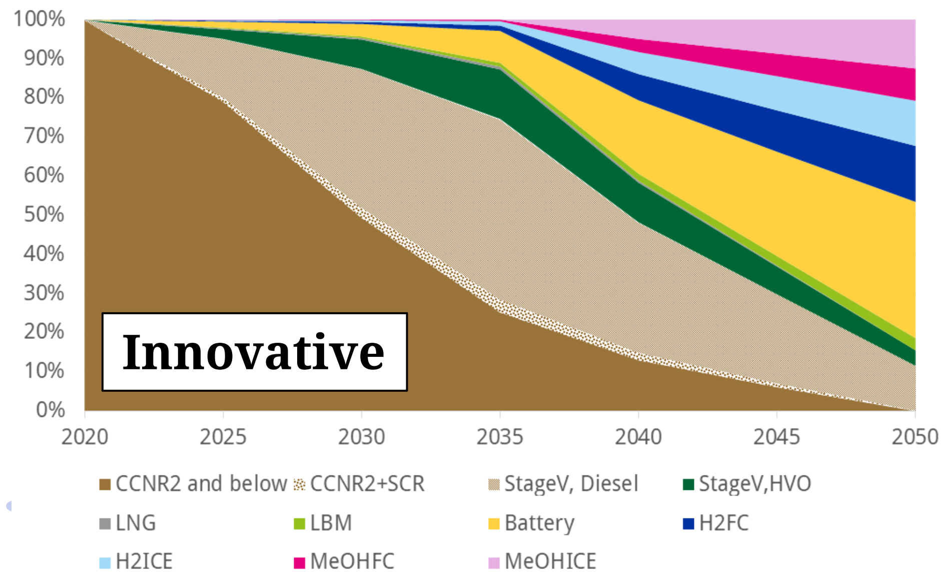
Page 1

# Prognoses for the scenarios



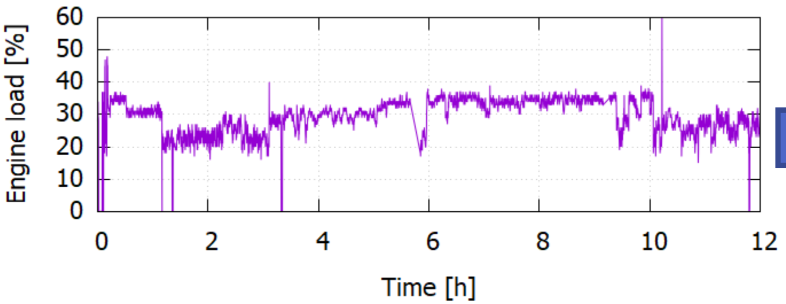



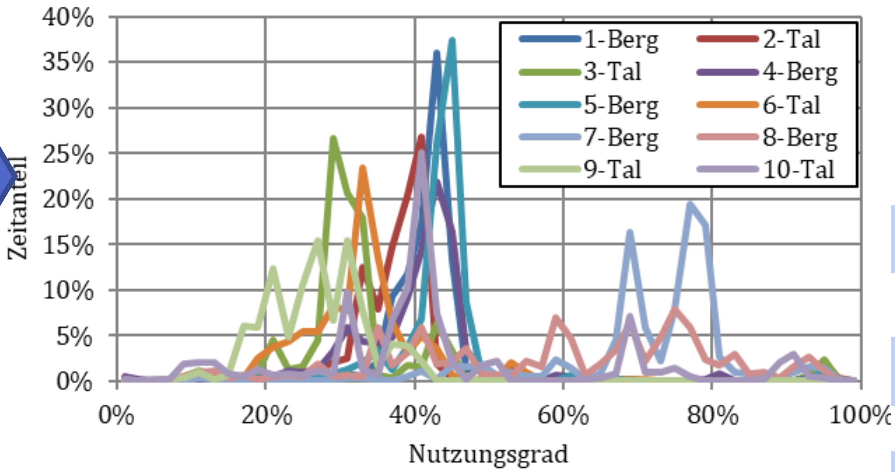



# Vessel-Specific measurements (PROMINENT (T5.4))

| Vessel | Monika Deymann |
|---|---|
| ENI | 02335636 |
| Loa | 134.99 m |
| B | 14.20 m |
| T | 4.00 m |
| Load capacity | 5558 ton |
| In service since | 2016 |
| Cargo type | Containers |
| Area of operations | Mainly Antwerp to Mainz |
| Main engine | 2 × Caterpillar 3512 DI-TA ELECTRONIC |
| Max power main engine | 1119 kW; 1520 hp |
| Type of propeller | 2 × fixed pitch ducted propellers |
| Diameter of propellers | 1700 mm |
| Measurements by | DST/ BAW |
| OBM since | 02-08-2016 |



# Possible next steps

- Collect existing information
  - Fleet and typical general arrangements (space)
  - Engine age, Emission standards
  - Fuel specification and consumption
  - Engine hours
  - Existing pilot applications
- On-board monitoring
- Assessment of suitable technologies (space, fuel, existing and upcoming regulations etc.)
- Development of strategy for roll-out plan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