Energy efficient navigation

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Outline

- Motivation to improve energy efficiency
- Possible optimization areas
- Physical background
- Empirical approach
- Prominent approach
- Conclusions

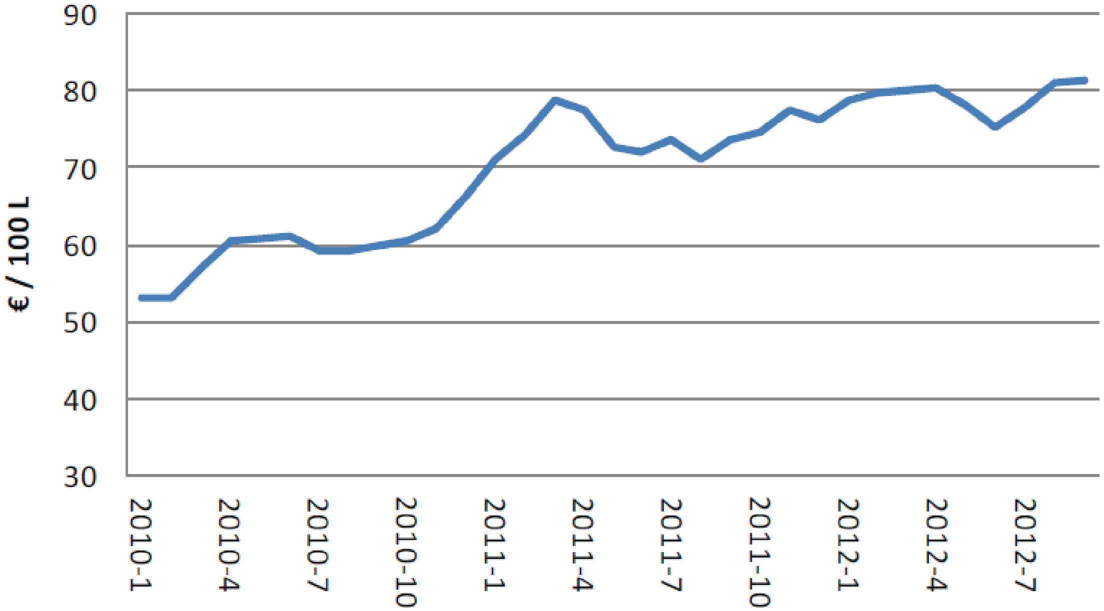
Motivation

Why energy efficiency matters:

- Fuel costs
- Emissions and ecological impact
- Regulatory framework
- Competitive environment
  (also with other modes of transport)

Motivation

Fuel costs at least 20% of operational costs in IWT



Source: Schweizerische Vereinigung für Schifffahrt und Hafenwirtschaft; CBRB.
* Gasölindex CBRB

Motivation

Cargo vessel (110 m x 11,4 m) on the Rhine	
Consumption	480.000 l/year
Spec. Fuel Costs	e.g. 0,68 €/l
Costs	326.400 €/year

Exemplary savings:

Reduction in %	Saved Costs in €
3	9.792
5	16.320
7	22.848
10	32.640

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Optimization areas

- Infrastructure
- Fleet modernization
- Logistics
- Hull efficiency
- Propulsion systems
  - Hydrodynamics
  - Engine and exhaust gas
- Qualification
- **Operational (sailing policy)**

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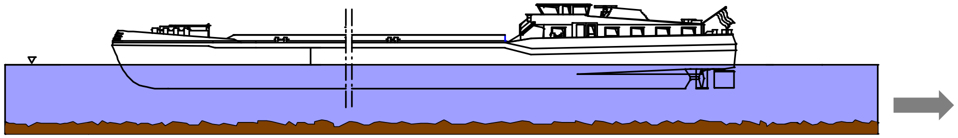
Physical background

Factors influencing operation in IWT

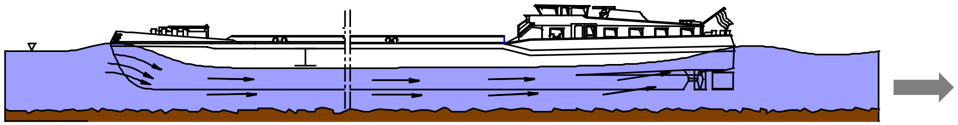
- Weather
- Current
- etc.
- Width of waterway
- Vessel type
- Water depth
- Curvature
- Traffic
- Sailing time

Physical background

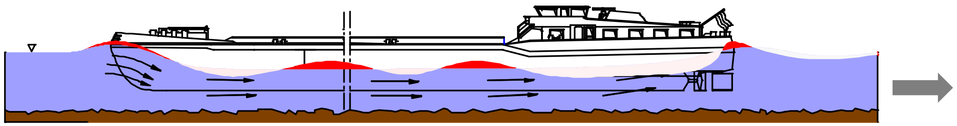
- Waves and displacement current



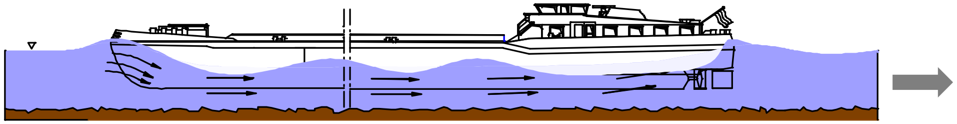
Ship at rest



Primary wave system



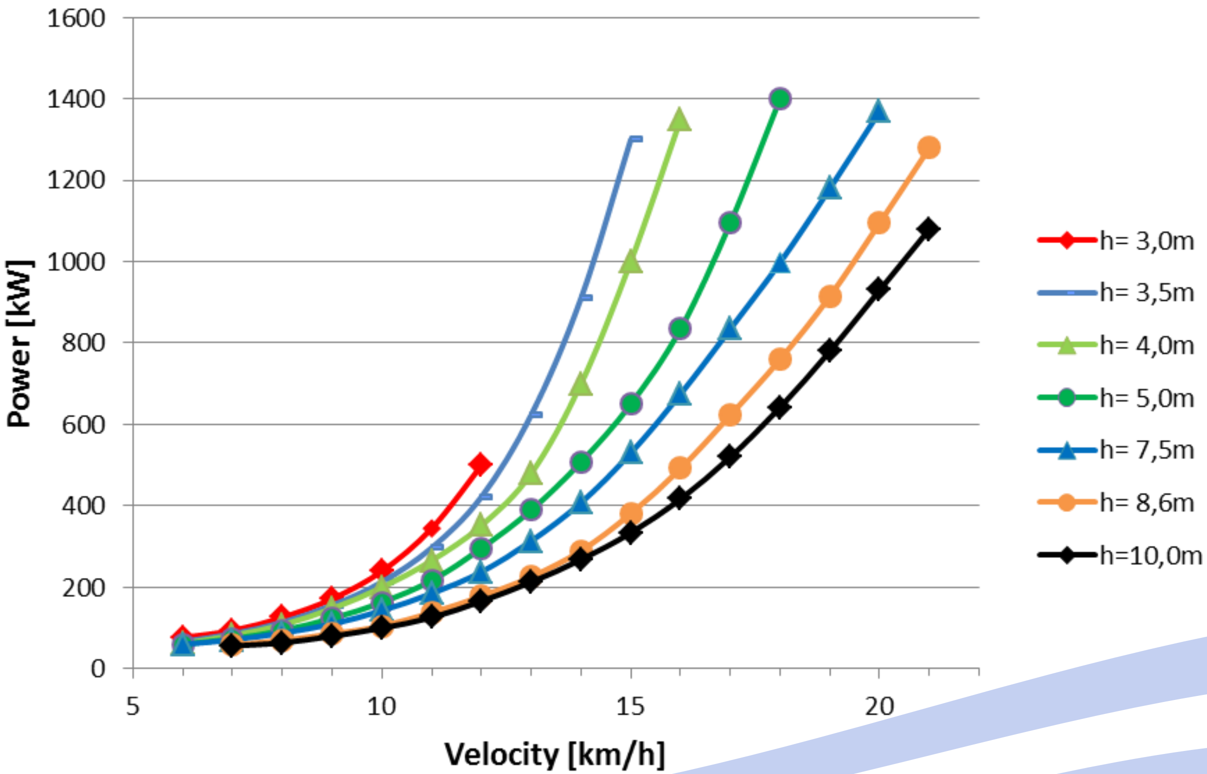
Secondary wave system



Combined

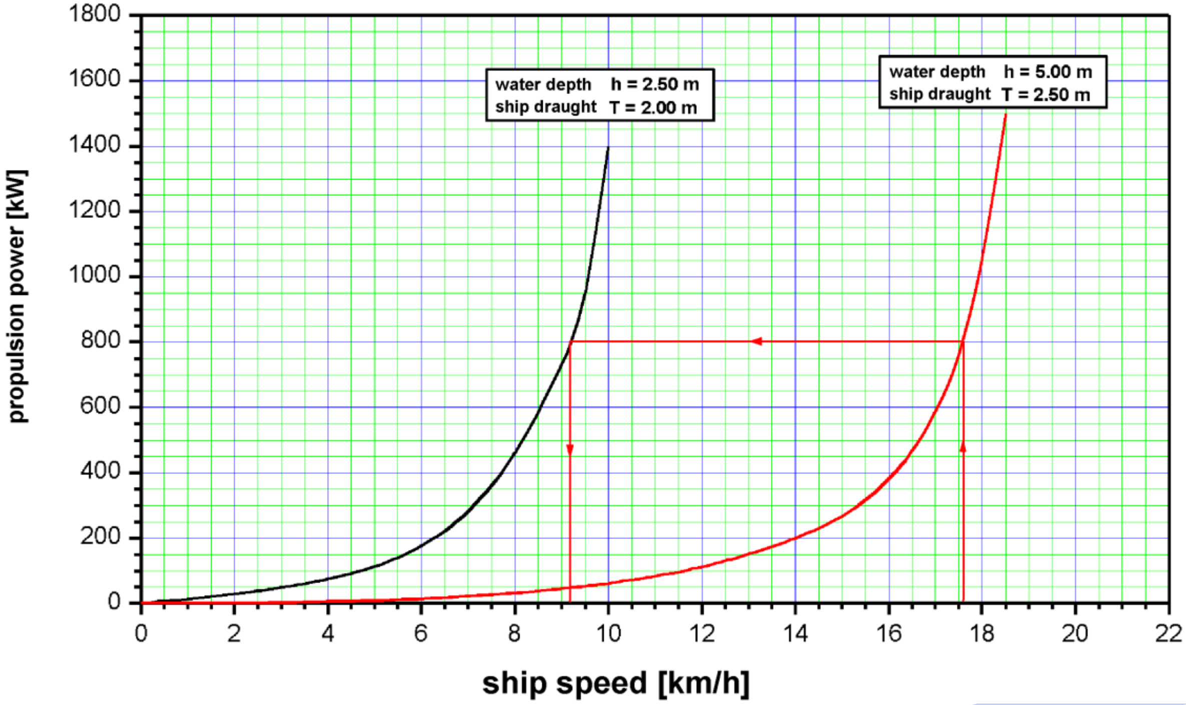
Physical background

- Power demand rises disproportionate with speed
- Power demand is increased by shallow water effects
- Speed is reduced at small water depth



Physical background

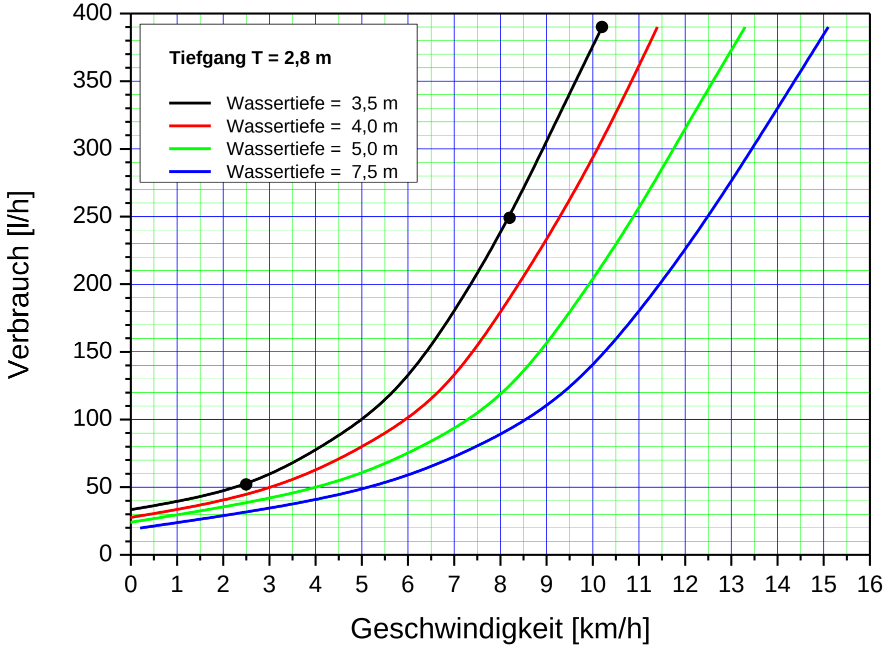
- Example: Europe-type ship (80 x 9.5 x 2.5 m, 1350 t)
- Reduced water level from: 5.0 m to 2.5 m
- Reduced ship draught: 2.5 m to 2.0 m



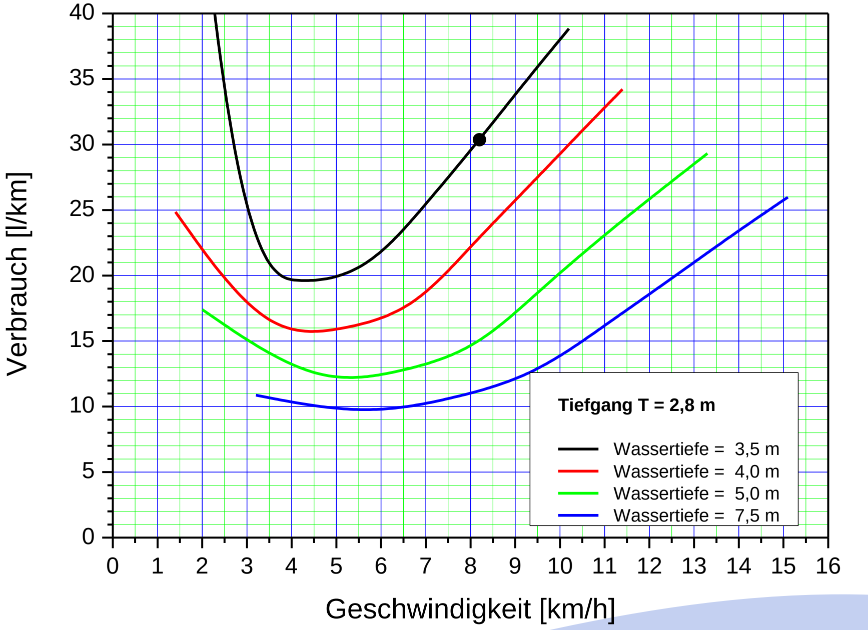
Physical background

Sailing against current:

Fuel consumption per time

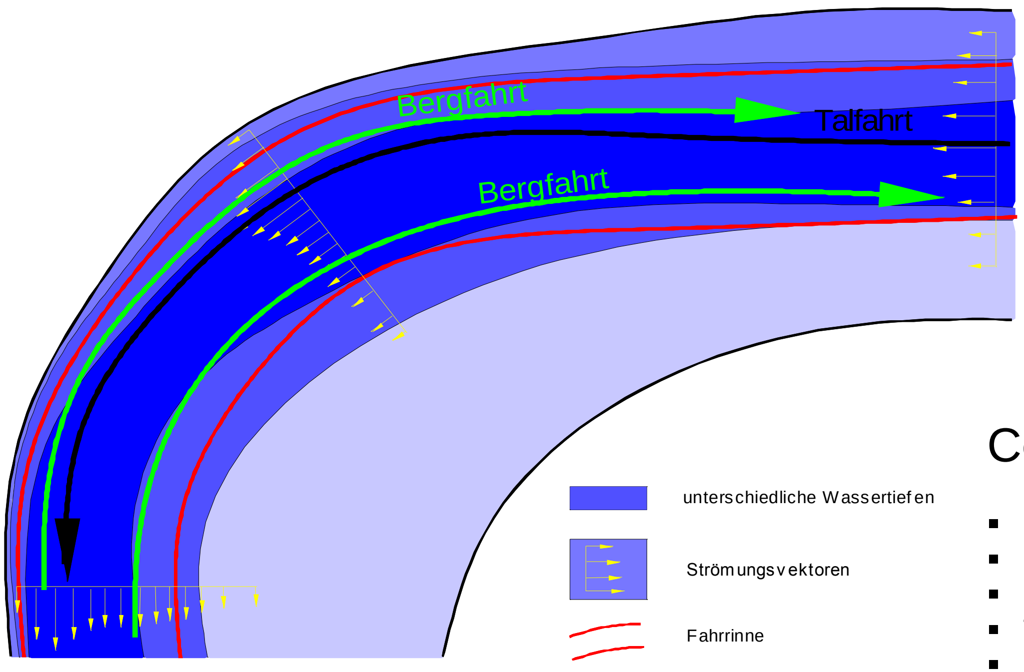


Fuel consumption per distance



Physical background

Track choice in bends

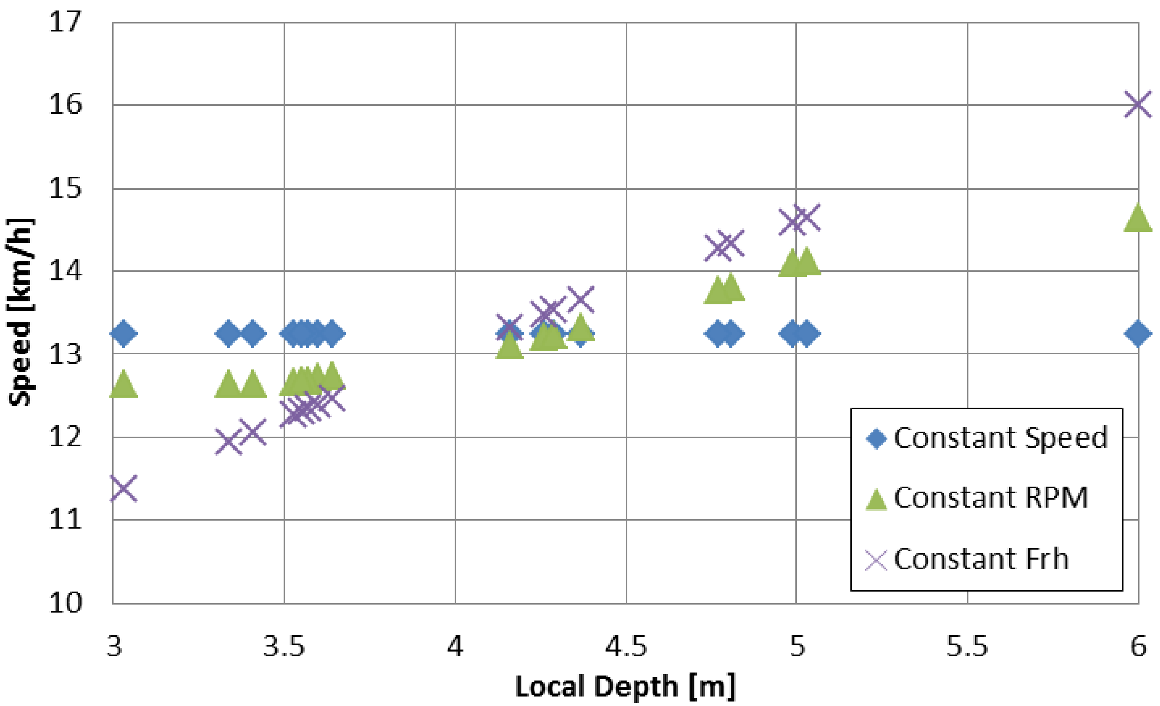


Conflict: Inside vs. outside

- Depth
- Current velocity
- Speed loss depending on radius
- Traffic
- Later track choice

Physical background

- What is the most efficient sailing policy?



- How to benefit from the physics?

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Empirical approach

Seminar Topofahrt (Classroom based):

- Basics: interaction vessel-waterway
- Gradual increase of complexity
  - impact of different water depths on fuel consumption
  - impact of different water depths and current on fuel consumption
  - impact of track choice on fuel consumption
  - (Trip planning) Reduction of fuel consumption through adaptation of speed to nautical conditions and corresponding track choice
- Step by step explained with examples
- Practical exercises
- Alternation of theory, exercises and simulator based training

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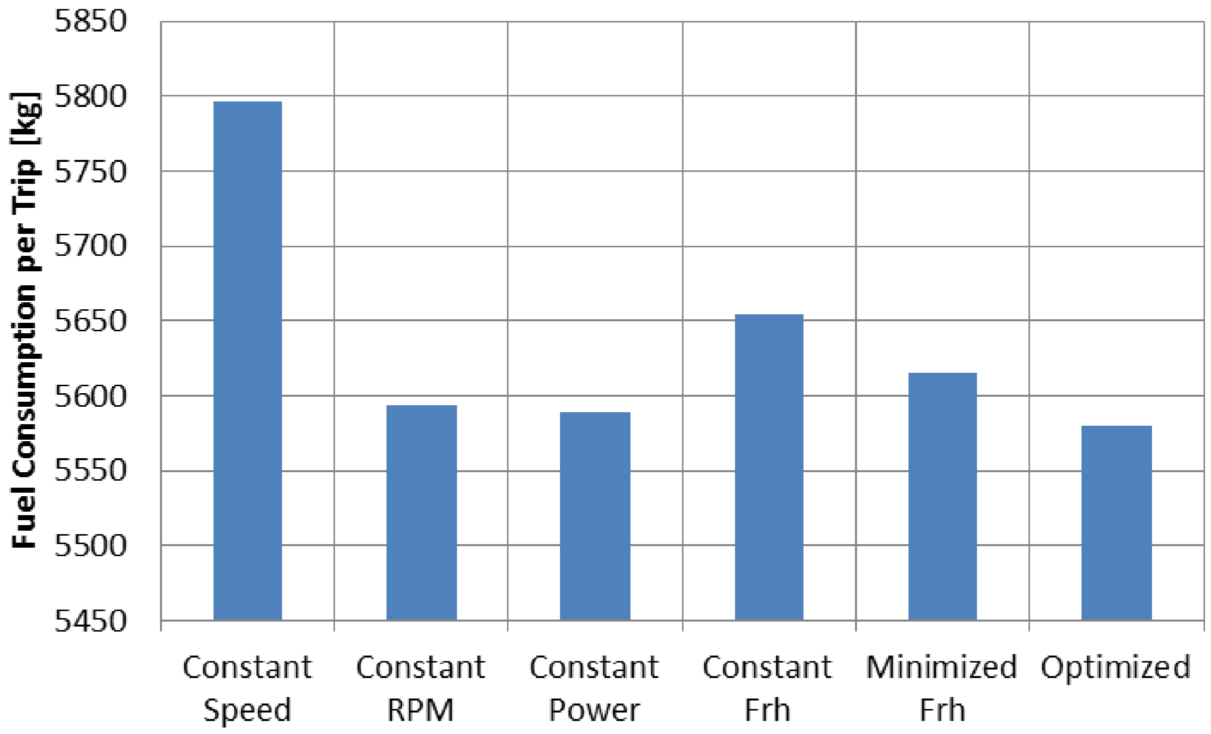
Prominent approach

Within the Prominent project (SWP 5.4) BAW, TNO, DST and others have teamed up to:

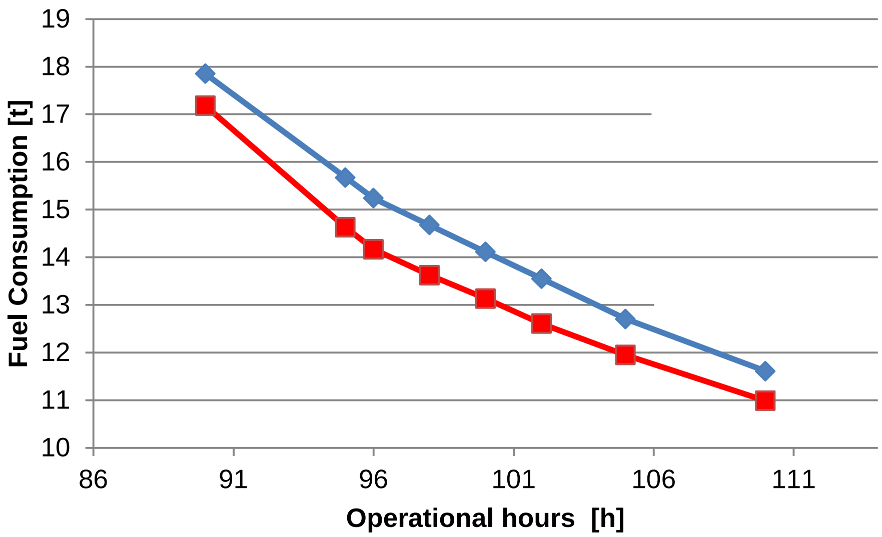
- Develop a novel trip advisory tool
- Optimization based on detailed waterway and ship data
- Comparison of sailing policies
  - Constant speed through water/over ground
  - Constant power
  - Constant RPM
  - Minimized average depth Froude number
  - Optimized speed profile

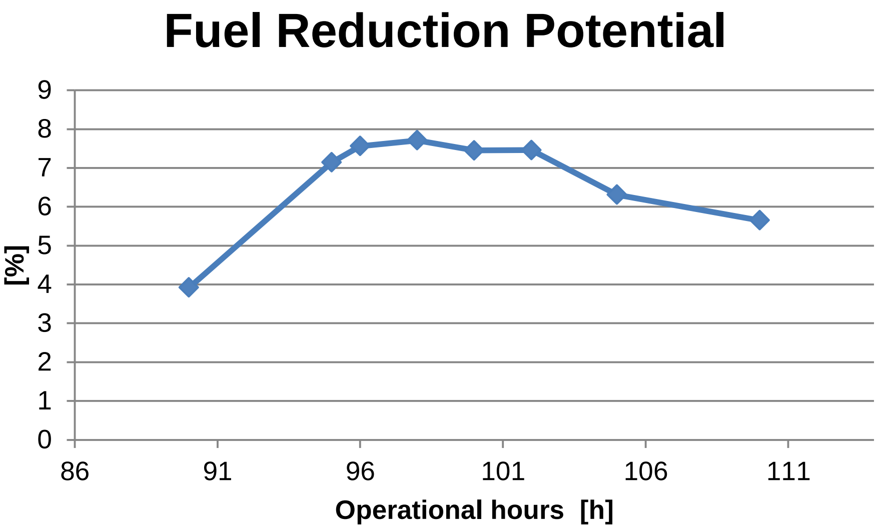
Prominent approach

- Sample journey at moderate water depths



Prominent approach





- Modelled journey based on segments and water depths of Rhine
- Initial sailing policy: Constant velocity through water
- Optimization: Reduce fuel consumption per trip at given sailing time
- Savings reduce with time getting closer to shortest possible time

Prominent approach

- Vessels are equipped with
  - precise echo sounders
  - directional GPS antennas
  - horizontal ADCP
  - …
- Dedicated model tests will be performed for three pilot vessels on the Rhine.
- Waterway authorities provide detailed hydrologic data.

Conclusions

- Fuel contributes significantly to operating costs.
- Combining different measures offers high potential for improved energy efficiency.
- No two trips can be compared directly in IWT.
- Awareness helps a lot.
- Smart Steaming is not only energy efficient but also cost efficient.
- Precise scheduling is most important and can be optimized simultaneously.

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