Interreg
EUROPEAN UNION
Danube Transnational Programme
GRENDEL

Towards green, efficient and competitive river Danube transport

Greening technologies

Things you might have heard before…

GRENDEL Final Event

Benjamin FRIEDHOFF (DST)

Project co-funded by European Union Funds (ERDF, IPA)

29 October 2020 • Virtual

Background

Source: ausstellungsschiff.de

Source: marsys.tu-berlin.de/menue/forschung/elektra/

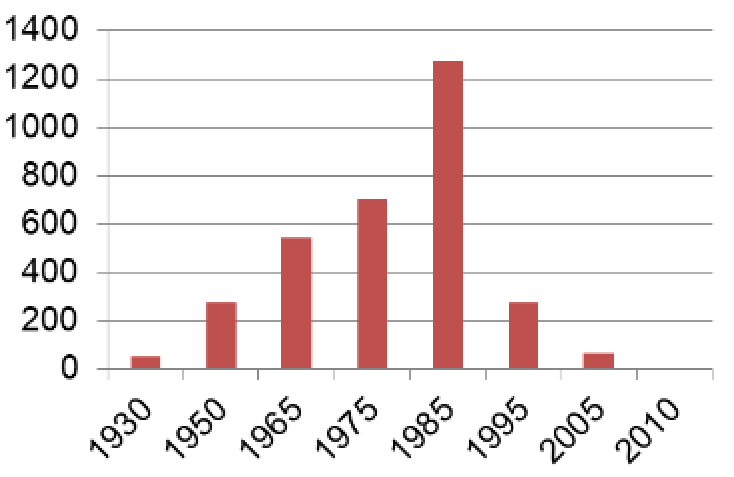
Source: www.vethpropulsion.com

Source: shipspotting.com

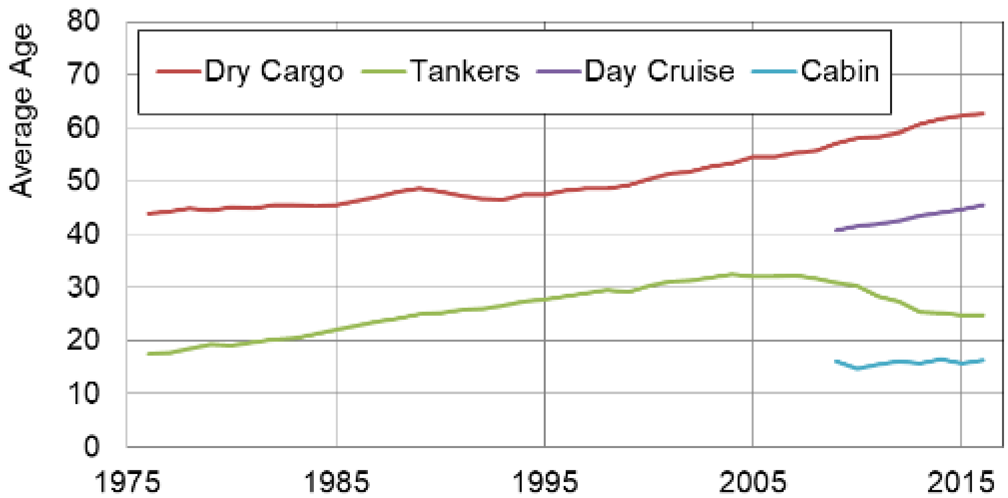
Background

- Congested roads + capacity on waterways + low energy demand → Modal shift desired
- Long lifecycles + low renewal of engines → Too high emissions of air pollutants
- Fleet modernisation and greening required →! Limited investment capacity

Danube Fleet:



German Fleet



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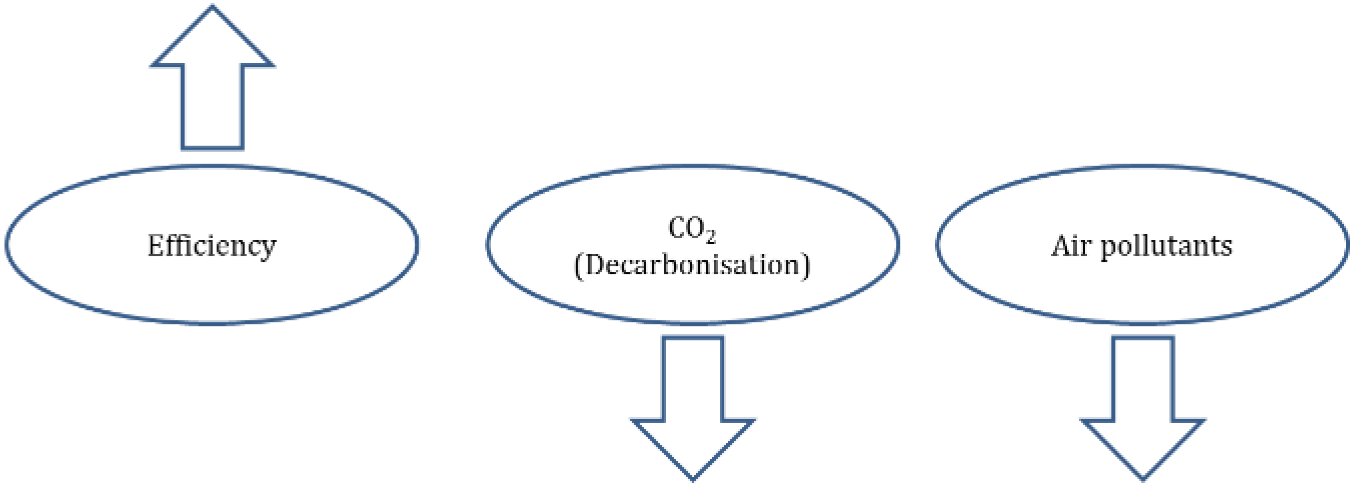
Background

- IWT sector has to invest for greening and new markets.
- Coordinated efforts required → GRENDEL
- Ultimate goal zero(-impact) emission
- Which technologies? Which transition pathways?
  Any business case? Who pays?

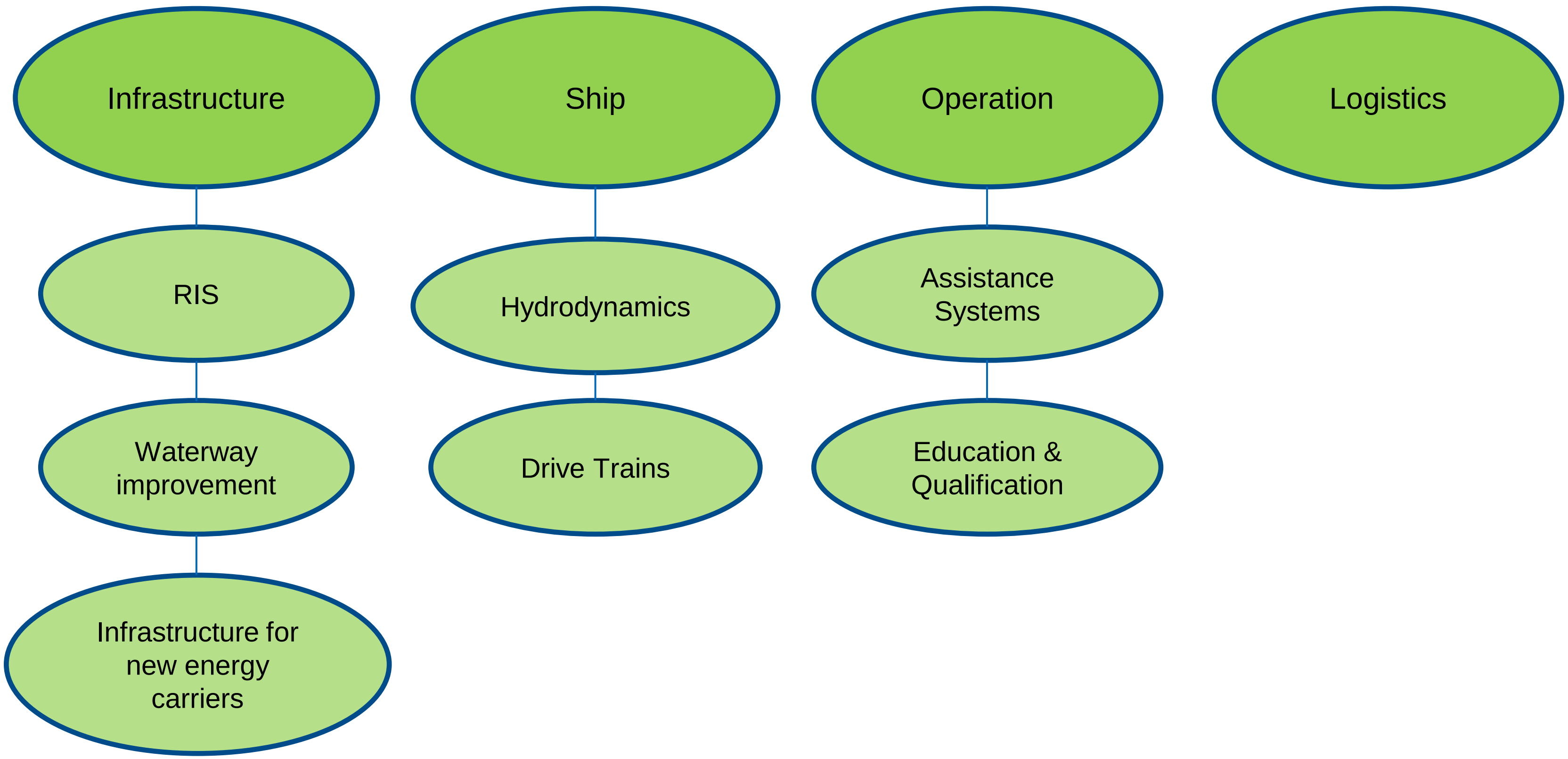


Know-how transfer

- Know-how transfer events.
- Dedicated selection of measures for the Danube region.

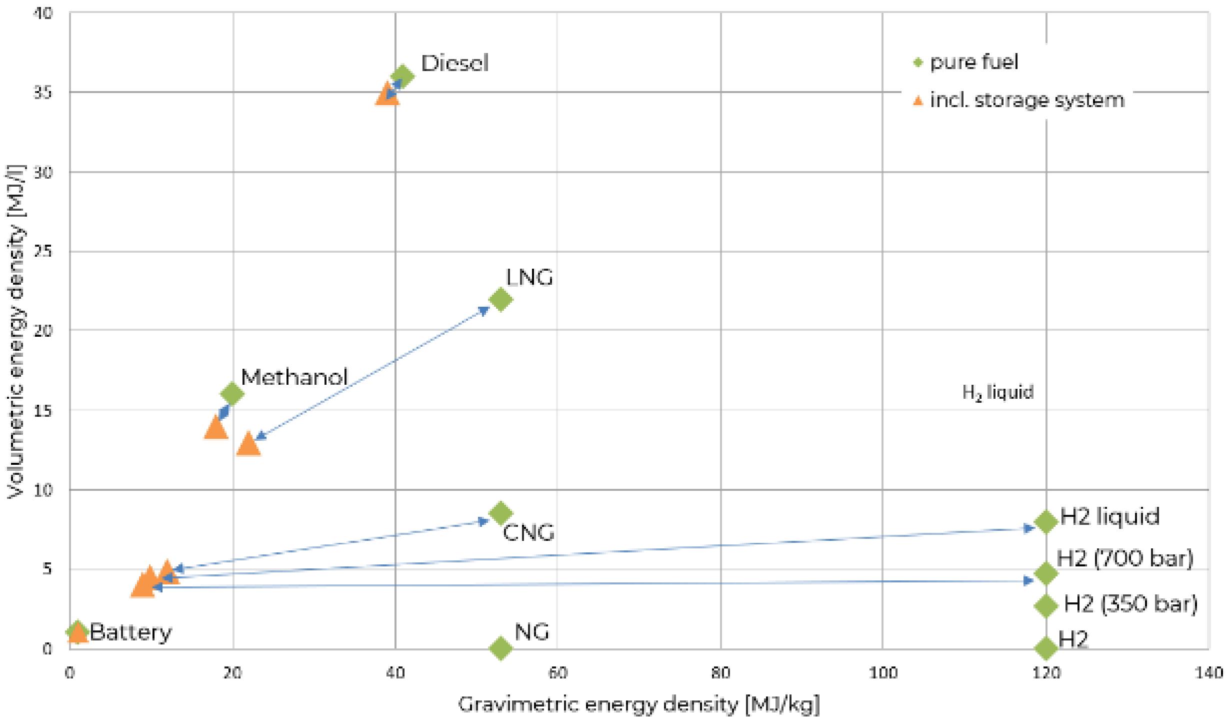
Background

Greening Options



Energy Transition

- **Tomorrow is now,** especially in IWT
- Mannheim Declaration:
  "[…] 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. […]"



Technological innovation factsheets

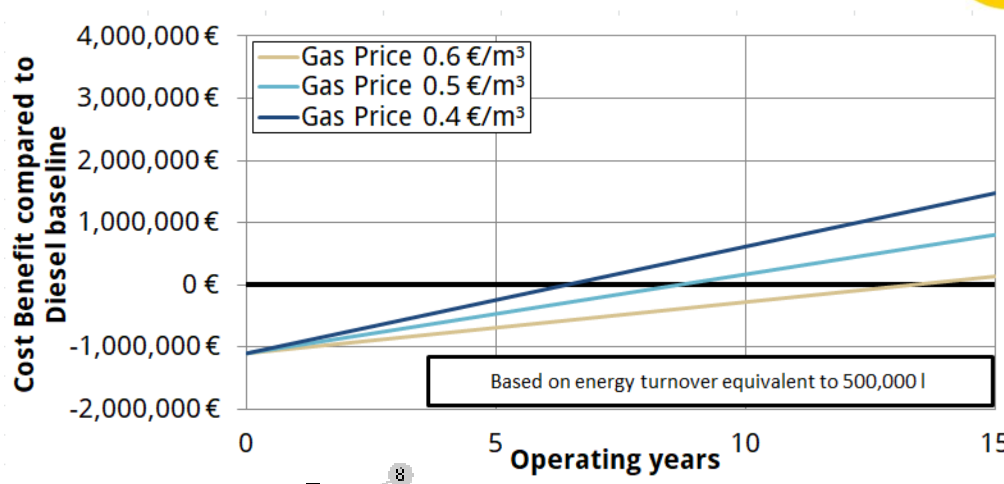
- **Info on Fleet Modernization**
- **No. 1** Gas and Gas-electric propulsion
- **No. 2** Diesel-electric propulsion
- **No. 3** After-treatment
- **No. 4** Fuel Cells
- **No. 5** Battery Electric Propulsion
- **No. 6** Drop-In (bio)Fuels
- **No. 7** Euro VI Truck and NRE Engines
- **No. 8** Energy Efficient Navigation

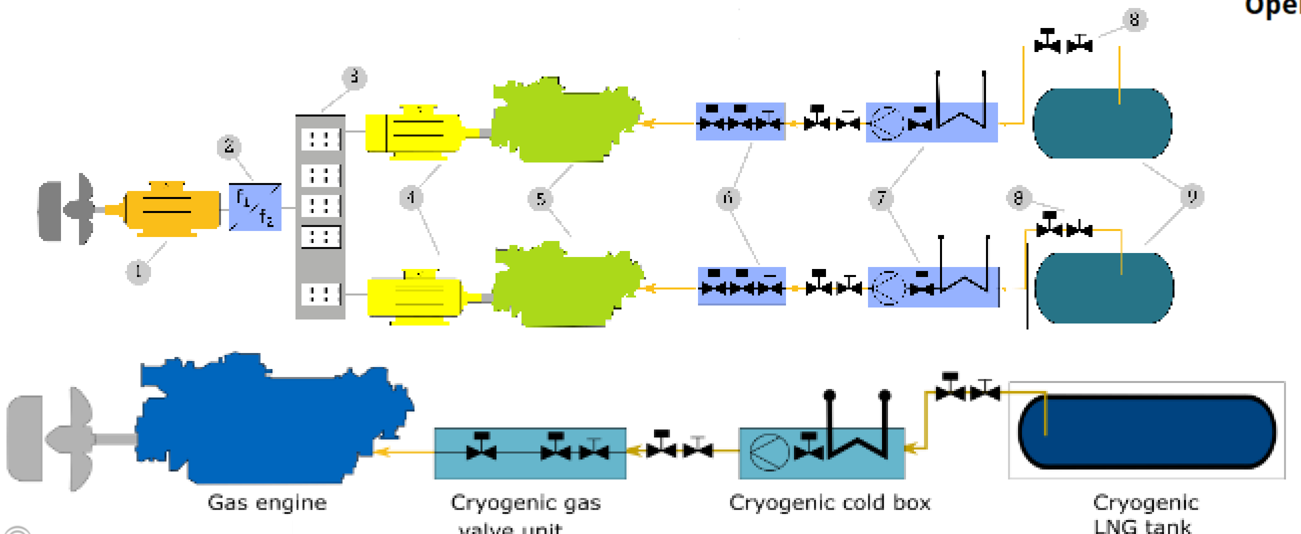
http://www.interreg-danube.eu/approved-projects/grendel/section/technological-factsheets

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

LNG / LBM

- From fossil sources or from biomass or from renewable energy (Power-to-Gas)
- Cryogenic pressure tanks
- CNG as option for moderate energy demand

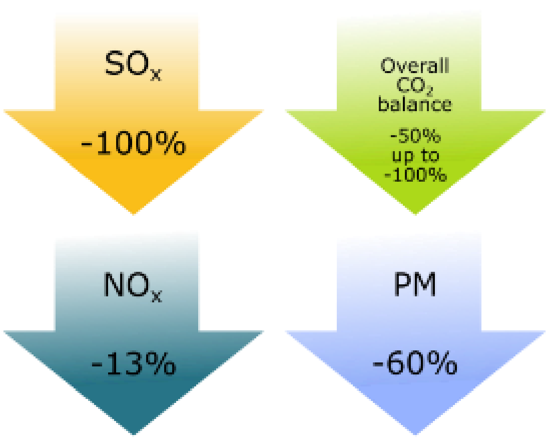


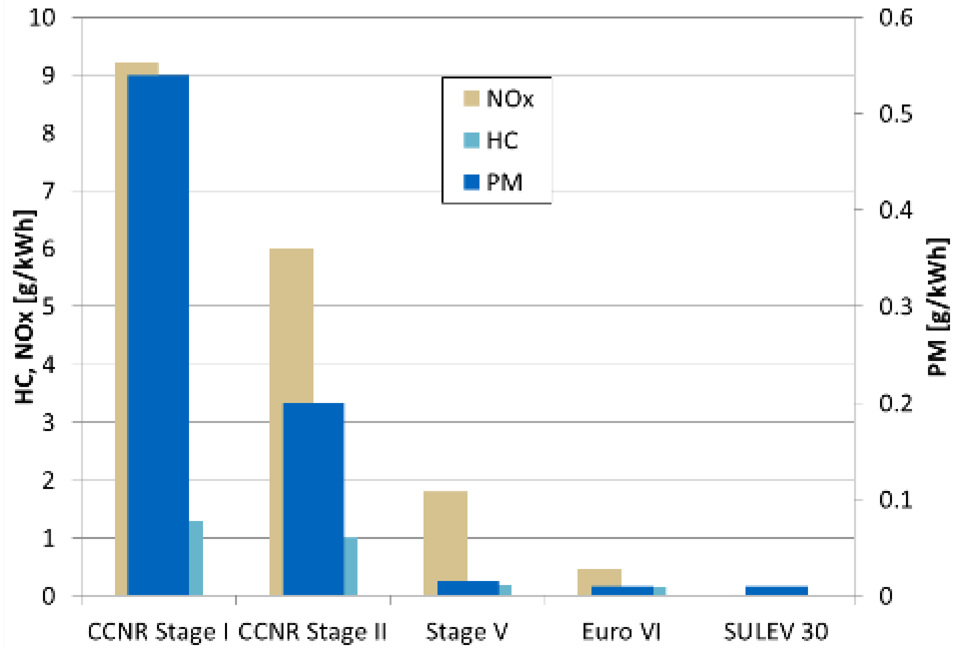


Drop-In (Bio) Fuels (in St. V engines)

- Gas-to-Liquid (GTL), Biomass-to-Liquid (BTL), Power-to-Liquid (PTL)
- 2nd and 3rd generation bio-fuels e.g. Hydrotreated-Vegetable-Oil (HVO)
- Marinised Euro VI and NRE engines
- Direct and diesel electric drive
- 90% target in reach
- Future availability for the sector?

- Synthetic fuels covered by EN15940
- Blends up to 100% (unlike FAME)





Exhaust Gas After-Treatment

Exhaust Gas Recirculation: NO_x ↓ PM ↑

Diesel Oxidation Catalyst (DOC): HC, CO ↓

Diesel Particulate Filter (DPF): PM ↓

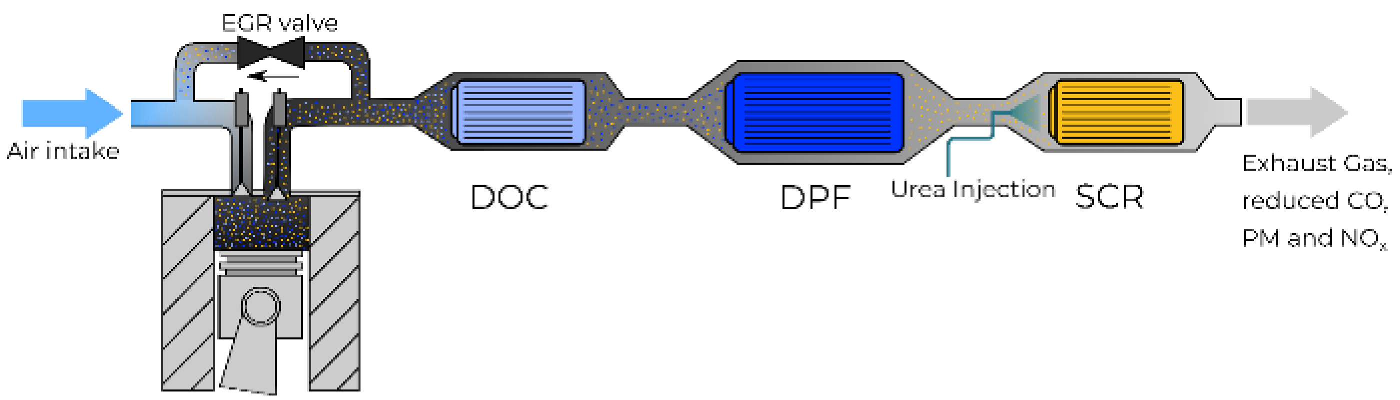
Selective Catalyst Reduction (SCR) No_x ↓

Efficiency ↑

AFTER-TREATMENT DESIGN

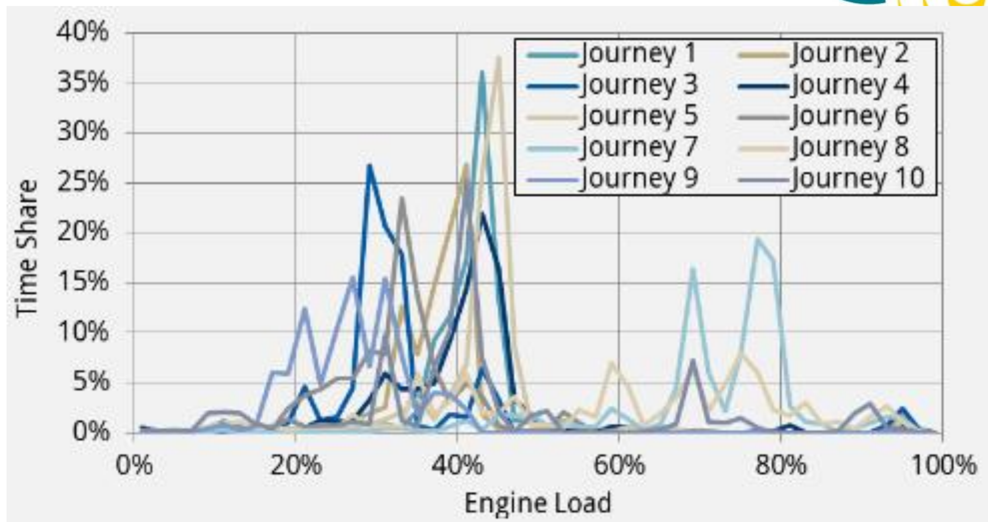
The design of after-treatment systems depends on prerequisites like:

- Exhaust gas temperature
- Allowable back pressure of the engine
- Operational profile
- Available space in engine room or on deck
- Mass flow rate of exhaust gas
- Engine condition

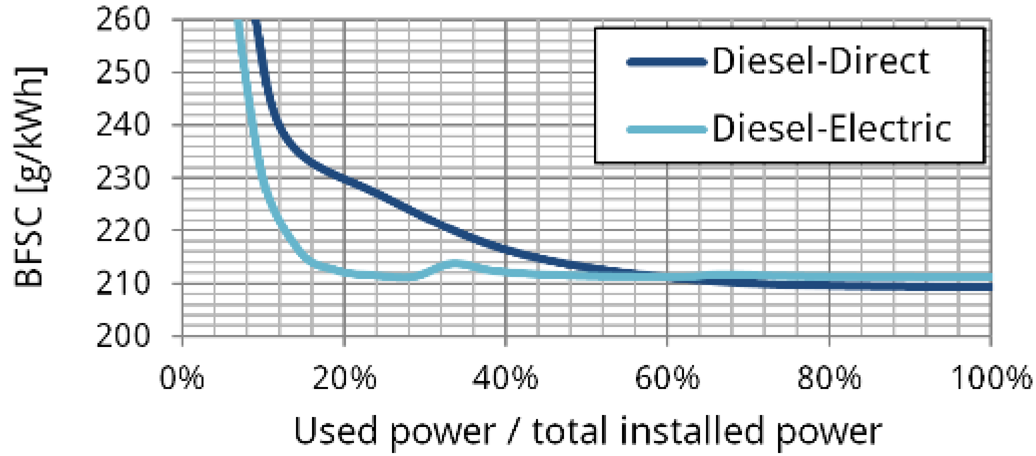


X-Electric Systems

- Ready for any power source
- Easier implementation of batteries and fuel cells

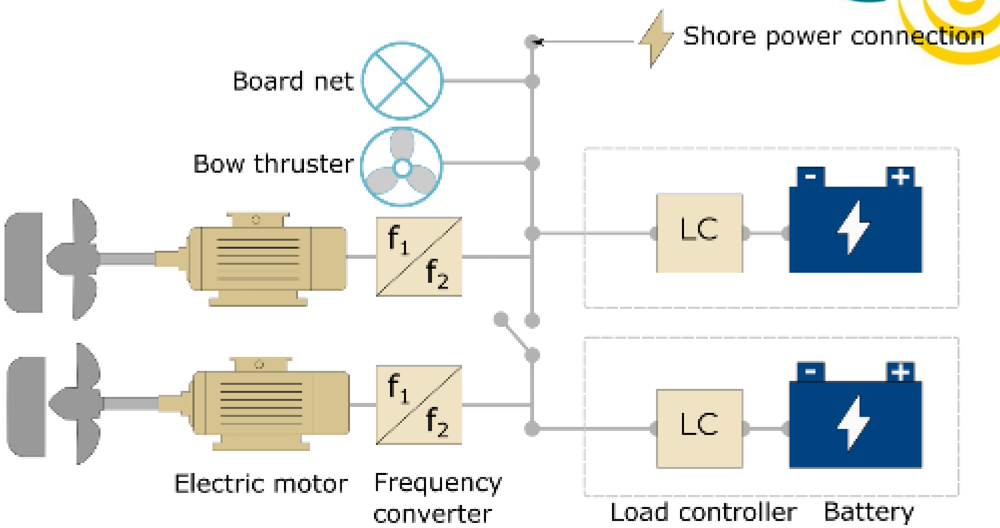


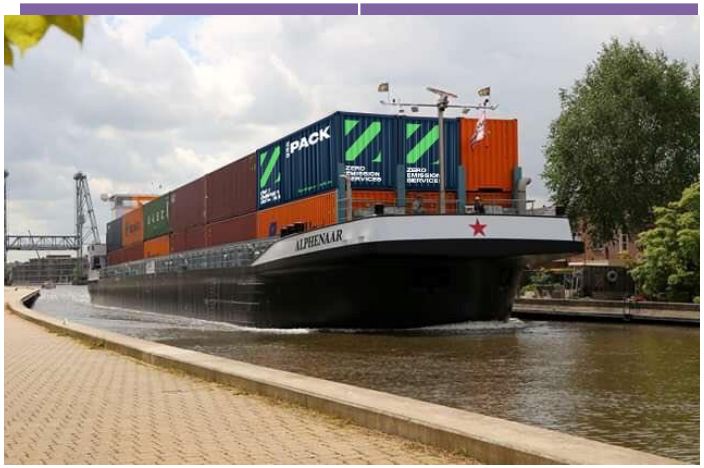
Advantages	Shortcomings
Engines run in their optimum	Investment costs
Increased overall efficiency	Additional losses
Silent	Weight
Lower emissions of air pollutants	Space
More flexibility to generate auxiliary energy	



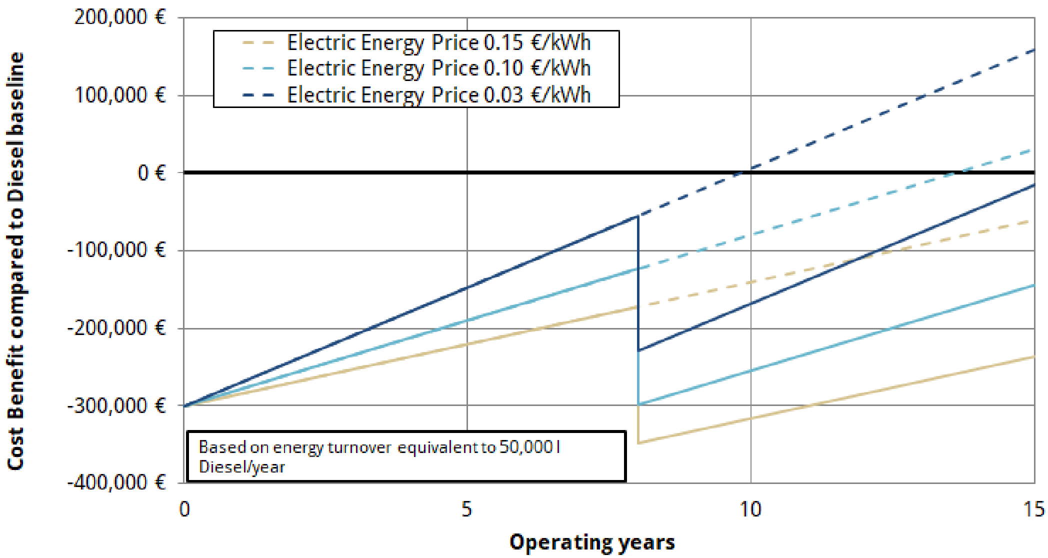
Battery Electric Sailing

- Charging on board or ashore
- Infrastructure for charging or exchange of battery containers
- Own battery or “energy-as-a-service”
- Good for peak shaving and local emission reduction





Source: Zero Emission Services B.V. (ZES)



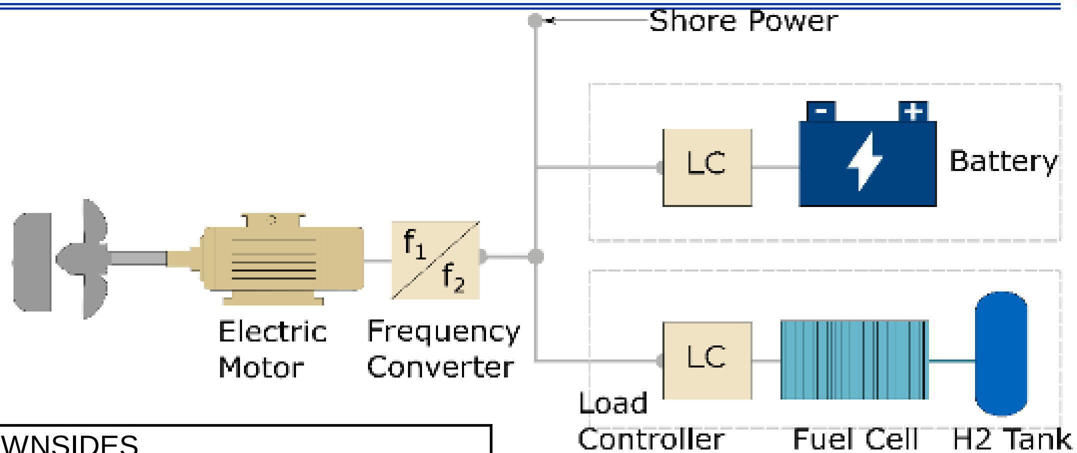
Hydrogen FC and ICE

Hydrogen

- Liquid in cryogenic tanks
- Compressed

Other energy carriers

- Methanol
- LOHC
- Methane
- Ammonia



BENEFITS	DOWNSIDES
• High efficiency at full load and (depending on application) at partial load • Good controllability • Good performance extension due to modular design • High development potential	• High investment costs • Operating experience in field test still low • Shorter useful life compared to market-dominating products (combustion engine) • Few suppliers

Energy Efficient Navigation

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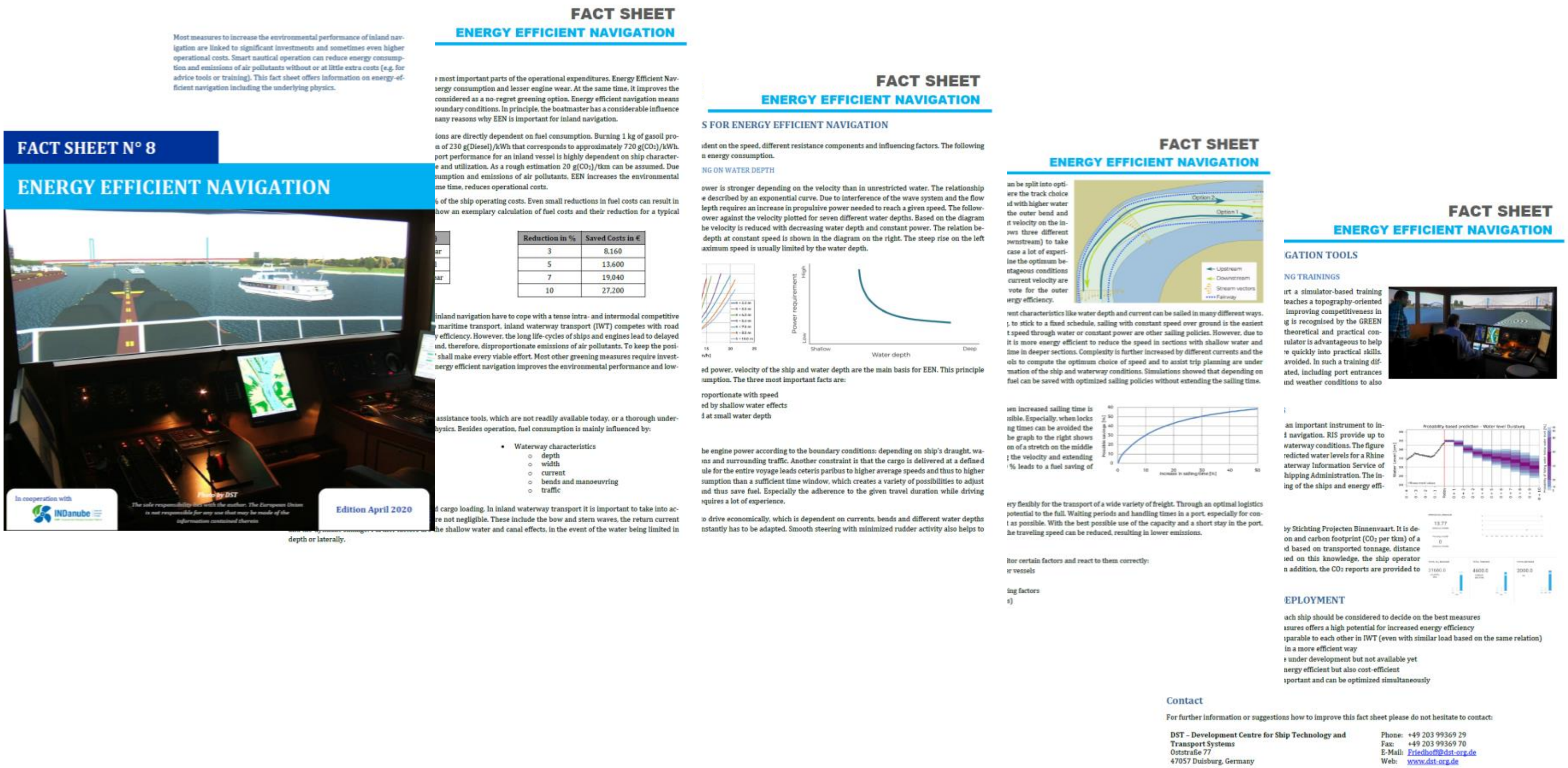

Recommendations

Depending on budget, ambition and time-frame:

- Awareness and energy efficient navigation
- Maintenance
- Consulting an expert
- Exhaust gas after-treatment
- Right-sized Stage V (IWA/IWP or NRE), Euro VI engine
- Diesel-electric drivetrain
- (Blending of) bio-fuels
- LNG for the matching application
- Battery
- Fuel-Cell (Hydrogen, Methanol, Ammonia)
- Ammonia in ICE…

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Photo: © NAVROM

GRENDEL "Green and efficient Danube fleet"

Towards modernisation & greening of Danube inland waterborne sector and strengthening its competitiveness

www.interreg-danube.eu/grendel

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