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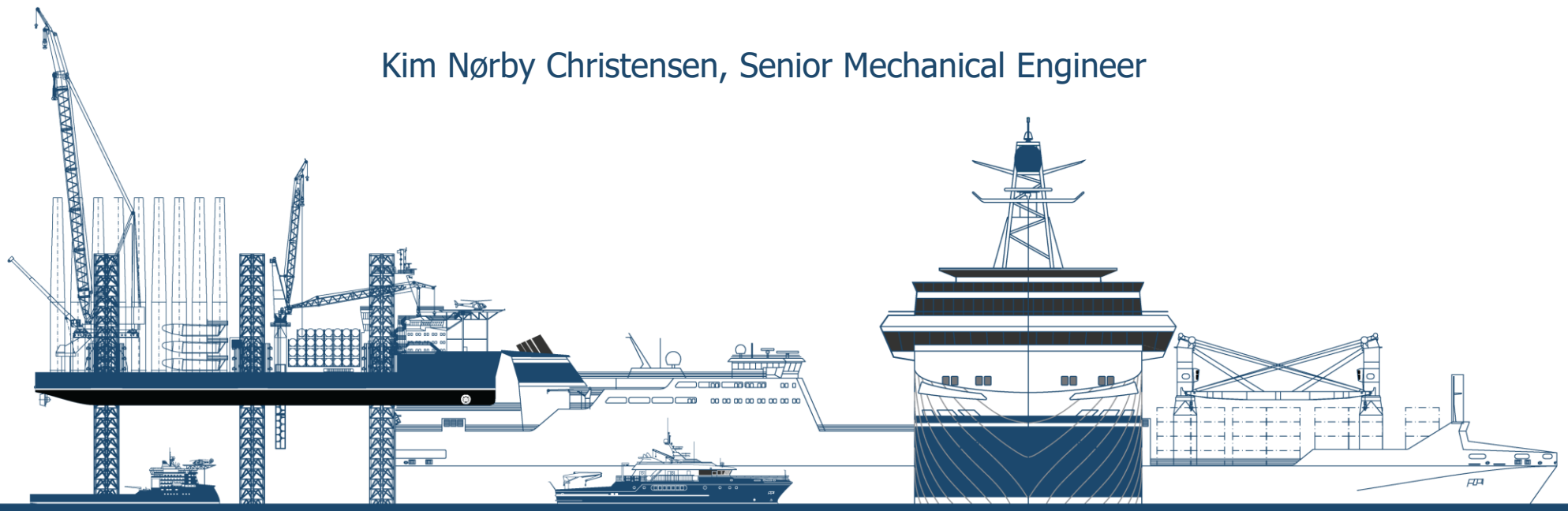
Future and Impact on Ships
From a ship designer's perspective

Kim Nørby Christensen, Senior Mechanical Engineer



KEH - WHO ARE WE AND WHAT DO WE DO
Naval Architects – Specialists in Ship Design

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- 86 years old company
- ~90 employees
- Offices across the world, e.g. at the Faroe Island

- Advisory for ship owners, e.g. about new fuels

- Concept, contractual and basic design for ship owners and yards (as usual up to the class approved level)

- Retrofitting and conversions
- A lot of work with calculations, design and engineering of new fuels

- To cut it short: We make sure the ship fulfils operational requirements and rules with best considered efficiency, and a lot of other stuff…

ONE REFERENCE

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Design by Knud E. Hansen A/S, Delivered 2022

Other fishing ships in the past, more in the future…

FROM A DESIGNER'S PERSPECTIVE
How New Technology Gets on the Market

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Development is driven by …

…POLITICAL GOALS

Initiator is the political goal for…

…ZERO CO2 EMISSION

Reaching sufficient CO2 reduction can only be reached by…

…CHANGING FUEL

Facilitator is the…

WHERE WE ARE

…NEW TECHNOLOGY

FUELS

DROP-IN FUEL (Net zero by 2050 goal not possible, temporarily)

Fuels that can be directly feed to an engine without modifications.

Same containment and systems as with traditional fuels.

Does not reduce particles, HC, CI, NOx and CO2 to zero.

- HVO100
- Etc.

GREEN TRANSITION FUEL (Net zero by 2050 goal possible, solution)

Requires development of engines, storage systems, batteries or use of fuel cells.

- Hydrogen
- Methanol
- Ammonia
- ESS (like batteries)

Subject to this presentation

OUTSIDERS

- **Carbon capture technology** is not considered as a viable technology yet (too expensive, too heavy, too space consuming), especially for smaller ships.

  We see really no projects where this is considered

  (CARBFIX could however change the picture locally in Iceland)

- **Nuclear**, well with the new reactors the concept is tempting but we do not see any considering it

- **Lower speeds** can be a part of the future energy reduction, but not for fishing ships, and does not solve the 2050 goals as such

Disclaimer, technology is developed fast so this is our picture at the moment

WHAT FUEL TO SHORTLIST?

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- Local fuel availability is the most important factor for deciding upon fuel
- We should not solve one problem by using energy to sail energy around the globe when locally produced energy is available (We need to look at the supply chain approach and not only the ship approach)
- Fishing ships not calling ports outside Iceland; hence fuel should be available at Iceland as to avoid CO2 footprint when importing

FUTURE IS IN EVERY DESIGN WE DO
3 Strategies

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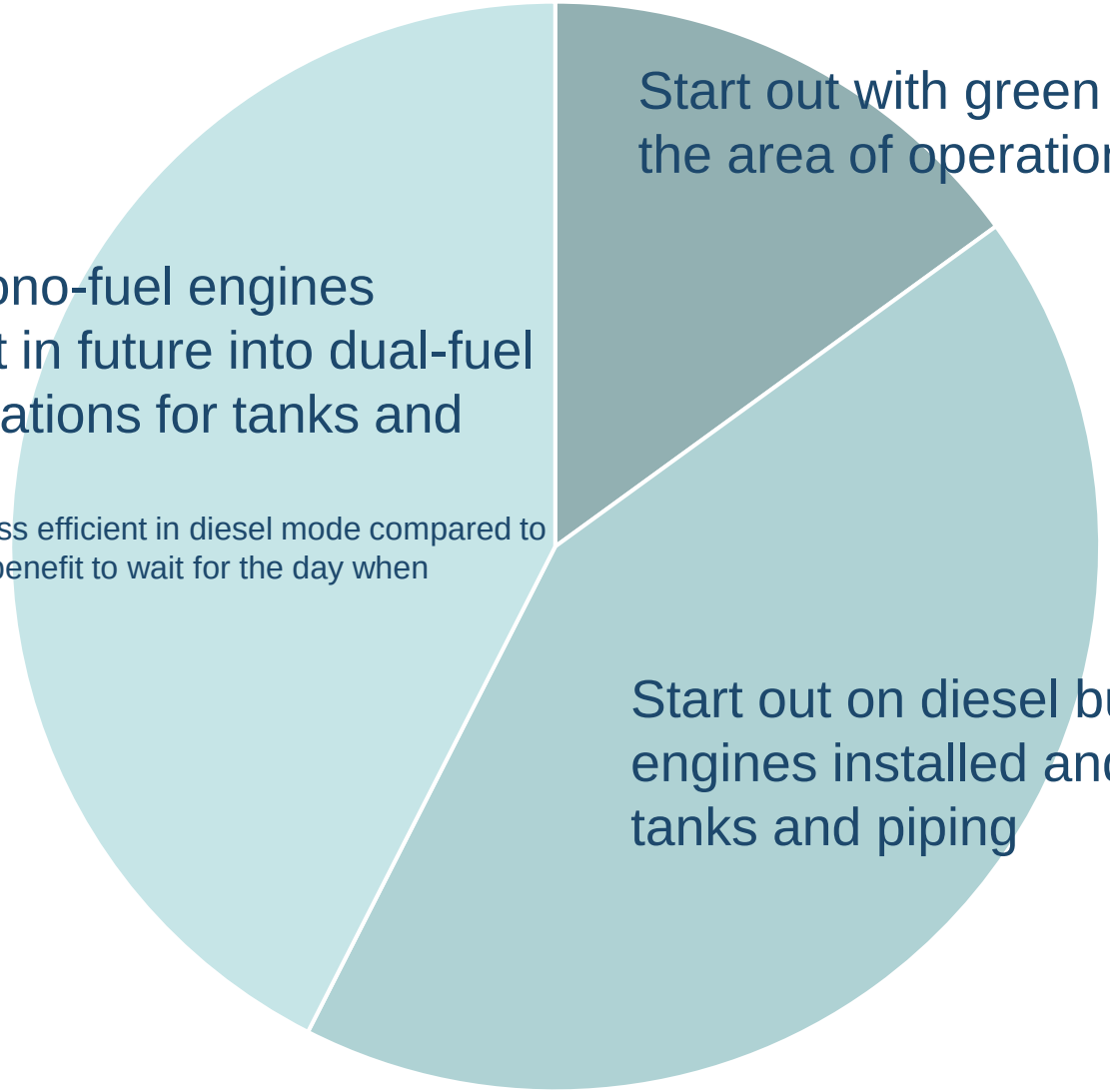

Start out with green fuel suitable for the area of operation

Starting out with mono-fuel engines preparing for retrofit in future into dual-fuel engines and preparations for tanks and piping

As dual-fuel engines are often less efficient in diesel mode compared to mono-fuel diesel engines it can benefit to wait for the day when green fuel is available

Start out on diesel but with dual-fuel engines installed and preparations for tanks and piping

THE PROJECT PROCESS

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- Selecting and integrating the right commercially available equipment for the ship
- Using commercially available rules from classes. Available for all new fuels
- Have been dealing with LNG for the past decade, so new fuels are no new
- Have carried out projects “big scale” with methanol, ammonia, hydrogen and batteries for at the past 5 years
- Implementing a new fuel or any other piece of equipment, is a traditional development design/engineering process managed by the designer

THE MAJOR CHALLENGE
Get Space for the Fuel Onboard

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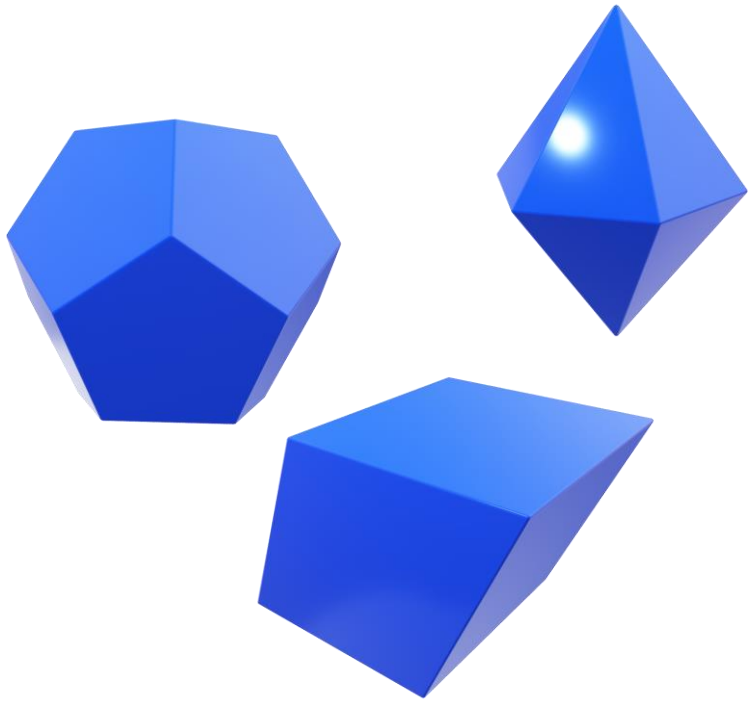
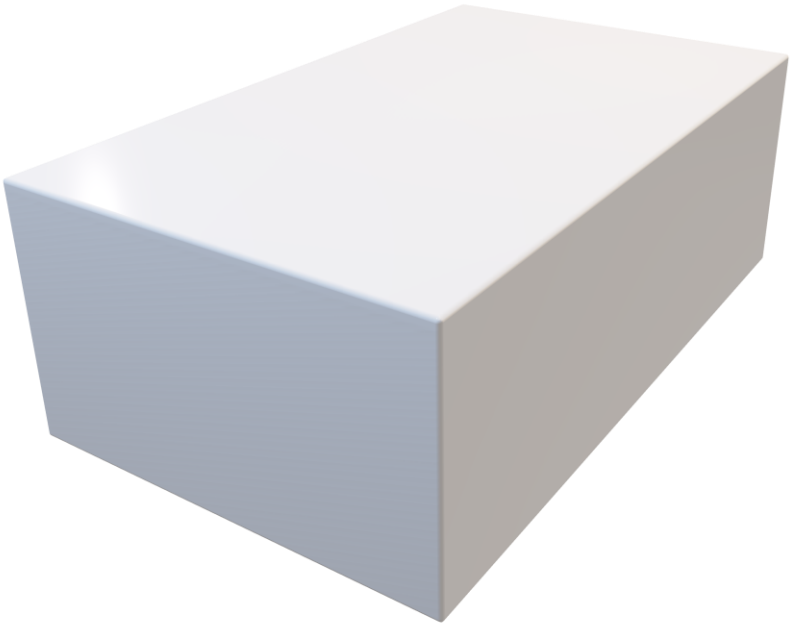
- For all projects, this is the challenge
- New fuel requires more space onboard and, in most cases, other locations

TRADITIONAL DIESEL TANKS

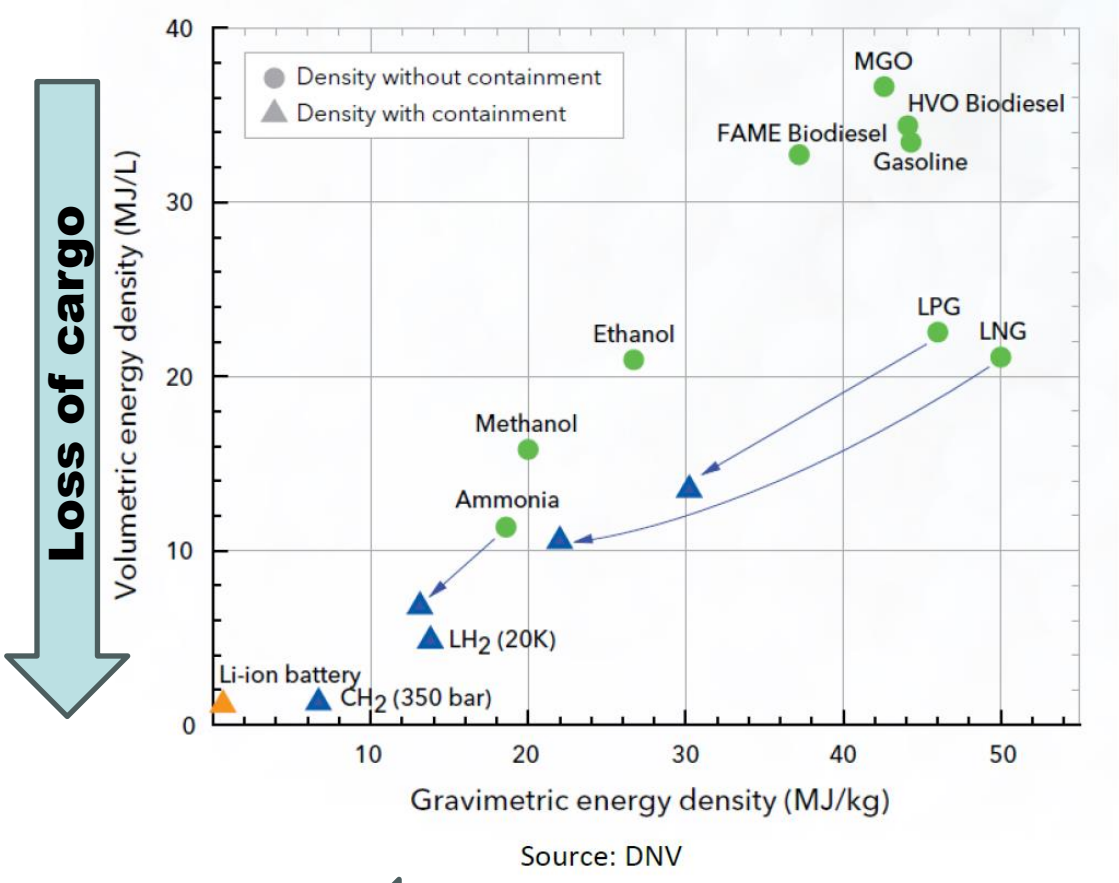


NEW GREEN FUEL TANK



THE MAJOR CHALLENGE
Get Space for the Fuel Onboard

- One rough conclusion can be made:
  - The cargo carrying capacity of similar ship will decrease!



Containment
Outsiders Not Included

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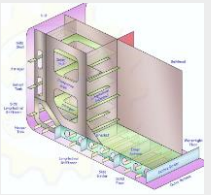
Fuel	State	Containment
Diesel	Atmospheric	
Hydrogen, gas	Small diameter cylinders with 300-500 bar	
Hydrogen, liquid	-253°C Vacuum insulated tank ~70% filling rate	
Ammonia	Ambient ~20°C 8,6 bar	
Methanol	Ambient temperature Atmospheric pressure N2 padded tank	Structural tanks with produceable cofferdams

CAPEX / OPEX
Now We Tie it All Up

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- CAPEX (i.e. building cost) for the ship will increase
  - Tank containment
  - Fuel supply system (diesel is still needed for backup)
  - Higher engine prices
  - Larger displacement/bigger ship to take same cargo (roughly speaking)
  - Waste heat recovery systems can be installed due to increased energy price
  - More efficient aux systems due to increased energy price

- OPEX (i.e. operation cost) for the ship will increase
  - More frequent bunkering due to lower endurance
  - Maintenance of new equipment
  - Increased electrical power consumption for handling of new aux systems
  - Fuel price means more expensive energy
  - CO2 tax shortens the return of investment (the “carrot” for making it more and more greener)

- Return of Investment for increased energy price
  - Waste heat recovery to be considered (e.g. ORC units)
  - Increased efficiency in aux systems

KEEP AN EYE ON
Fuel Cells

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- We use engines for 98% of our projects today
- Solid oxide fuel cells (SOFC) is comming
- Not yet ready for marine use, yet
- Can use methanol or ammonia directly to produce electrical power
- High efficiency, especially in future

Retrofitting = Asset Management
Keep Value of Your Fleet

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- If newbuilding is a struggle, retrofitting is totally exhausting, finding the space for fuel containment is the tricky part, especially because the ships are somehow small and filled with equipment

- Keep in mind, it is not only to find the space, we also need to consider:
  - Stability (moving fuel from bottom to upper part in heavy containment systems is not beneficial)
  - Cargo impact

Turn Back Time
When LNG Started

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- LNG has been used for fueling ships for a decade (similar fuel as many of the new fuels)
- Introduced based on the SOx and NO x emission reduction requirements from IMO
- Slow start because LNG distribution in small scale was not available (and here LNG was already available in all major ports but not for fuel, only distribution was needed)
- Transition to new fuels; fuels needs to be available as well as distribution, then transition of the fleet will follow

Container Ships Trend

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- Jonas told me that he would like KEH to briefly touch upon container ships as these are carrying the cargo from Iceland to Europe

- KEH is involved in conversion projects with container ships (among others) to methanol

- When APMM decided to go for methanol some years ago it moved the market in that direction

- Methanol and container ships are really a kind of ideal combination due to the nature of the methanol storage

SYSTEMS THAT WE IMPLEMENT AND DESIGN

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- Container ships calling Iceland is relatively small ships powered by 4-stroke engines; while the big containerships are using 2-stroke

- 2-stroke runs on almost everything..

- …but for 4-stroke, the market is emerging, and a limited number of engines/power units are available right now

- Containerships, by nature goes to Europa; hence most likely fueling in Europe and not in Iceland
- Iceland does not need to produce fuel for containerships if endurance is based on a round trip; if fueling in Iceland container ships will compete with local market

- We see projects with very limited capacity due to space of new fuels, but for e.g. container ships the trend is not an each-port-refueling strategy