

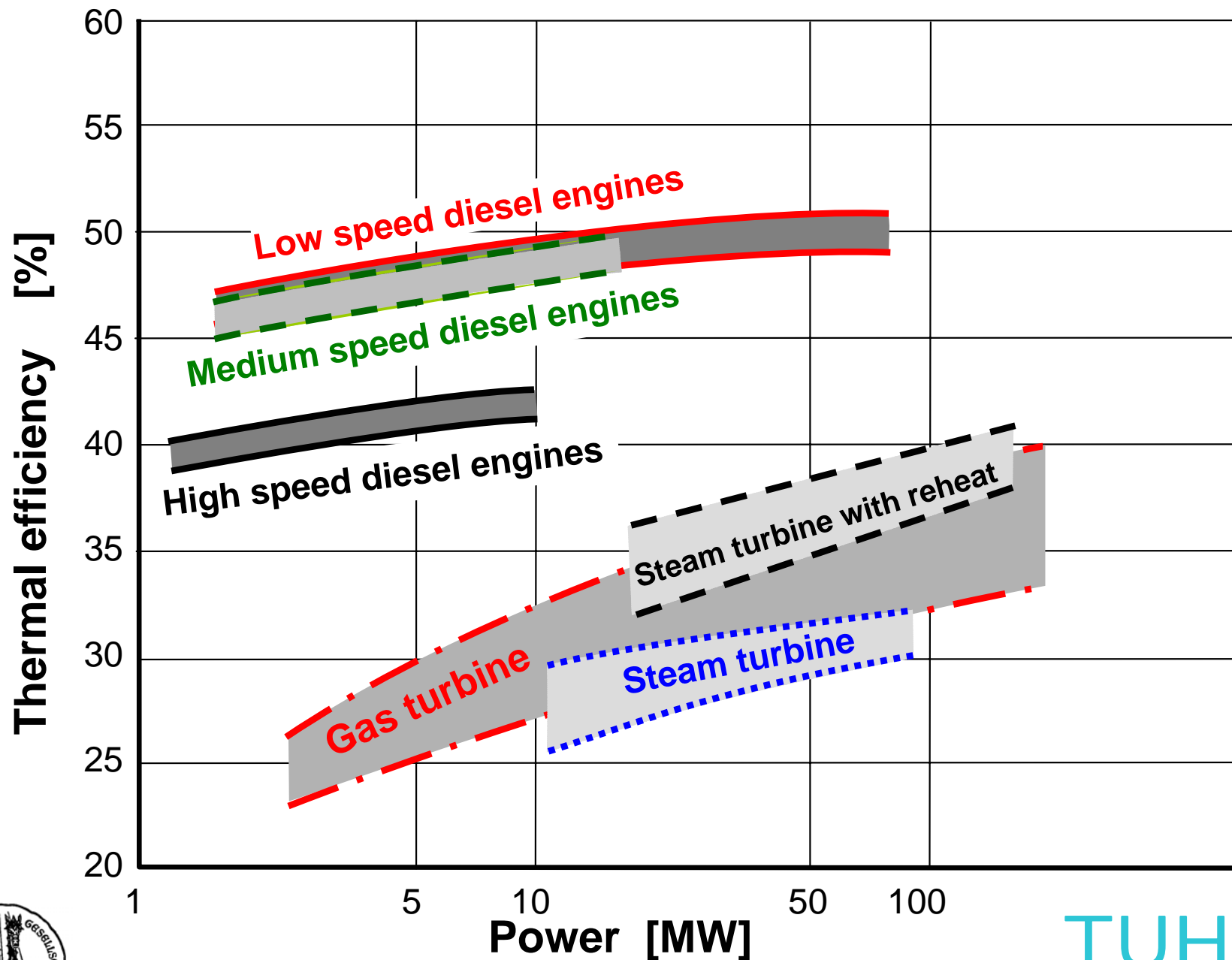
Marine Heavy Fuel Oils - Problems and Alternatives -



- Historical development of heavy fuel operation and qualities
- Engine problems related to heavy fuel oil
- Environmental aspects of HFO
- Possible alternatives



Efficiency of Propulsion Systems



Main Characteristics of Diesel Engine Fuels

- Exothermic oxidation
- Flowability
- Lubricity
- Combustion without excessive acid and ash formation



History of Combustibles for Internal Combustion Engines:

- Shooting powder (1680; Huygens)
- Hydrogen (1807; de Rivaz)
- Coal gas (1858; Lenoir)
- Kerosene (1873; Brayton)
- Gasoline (1885; Daimler)
- Petroleum (1893; Diesel)
- Biofuel (Peanut oil) (1898; Diesel)
- Coal dust (1899; Diesel)
- Residual fuel (1909/ 1912; MAN / Junkers)
(1948; Lamb)



“In future only residues, which remain after the distillation of crude oil, will be used in ship operation. (...) Engine tests confirmed, that it is possible to burn these residues in diesel engines.”

T. Saiuberlich (Annual STG meeting 1912)



Heavy Fuel Operation of Marine Engines :

- **Early 1950s :** **First HFO operation of slow speed marine engines**
- **Early 1960s :** **Increasing HFO operation, also medium speed engines**
- **1970s :** **Combustion of heavy fuels in all main engines of merchant fleet ($P_e > 2000$ kW)**
- **1990s :** **HFO operation of many auxiliary engines (One-Fuel-Ship)**

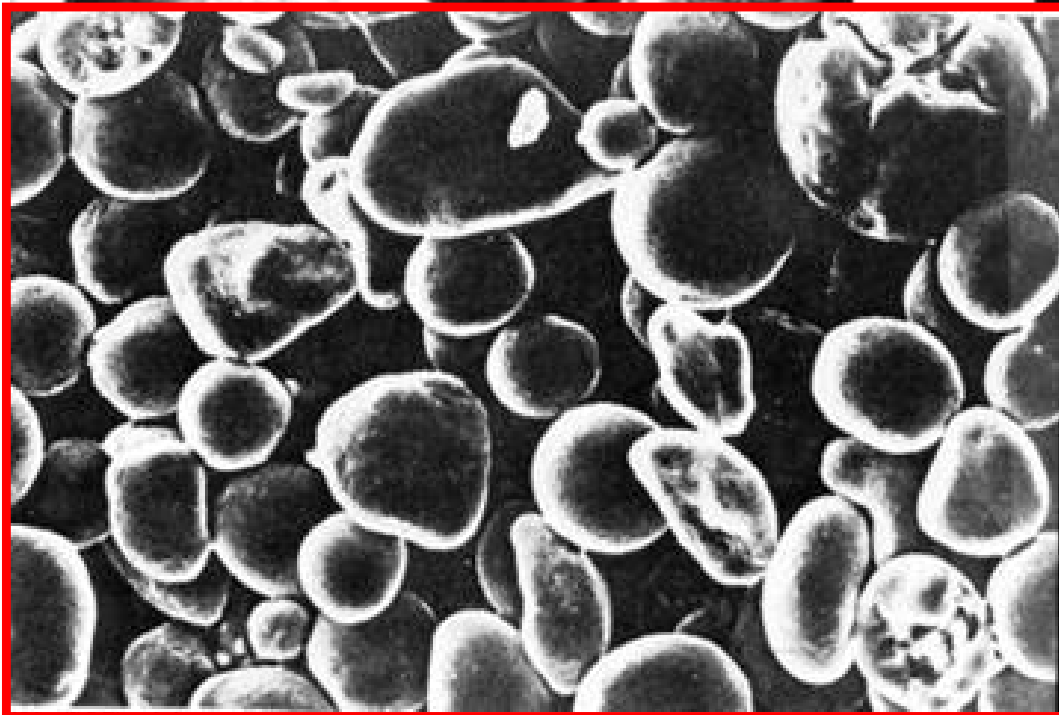
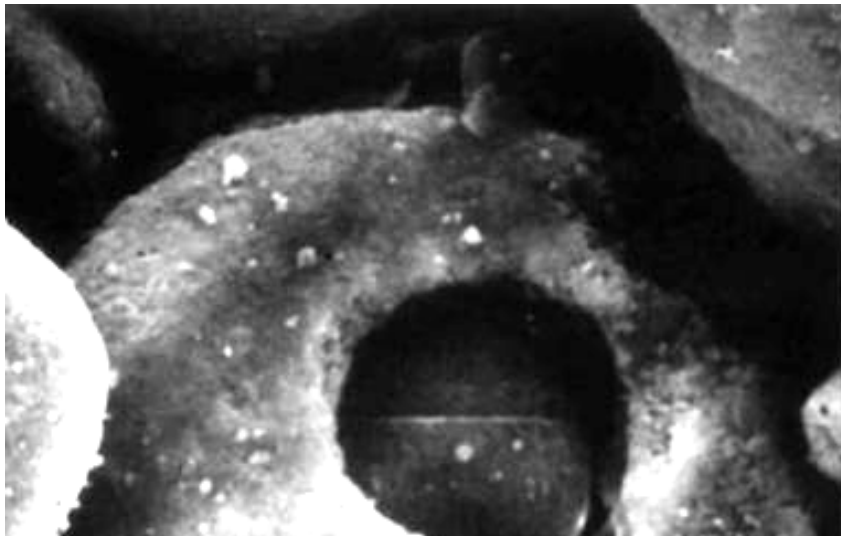


Development of HFO Operation

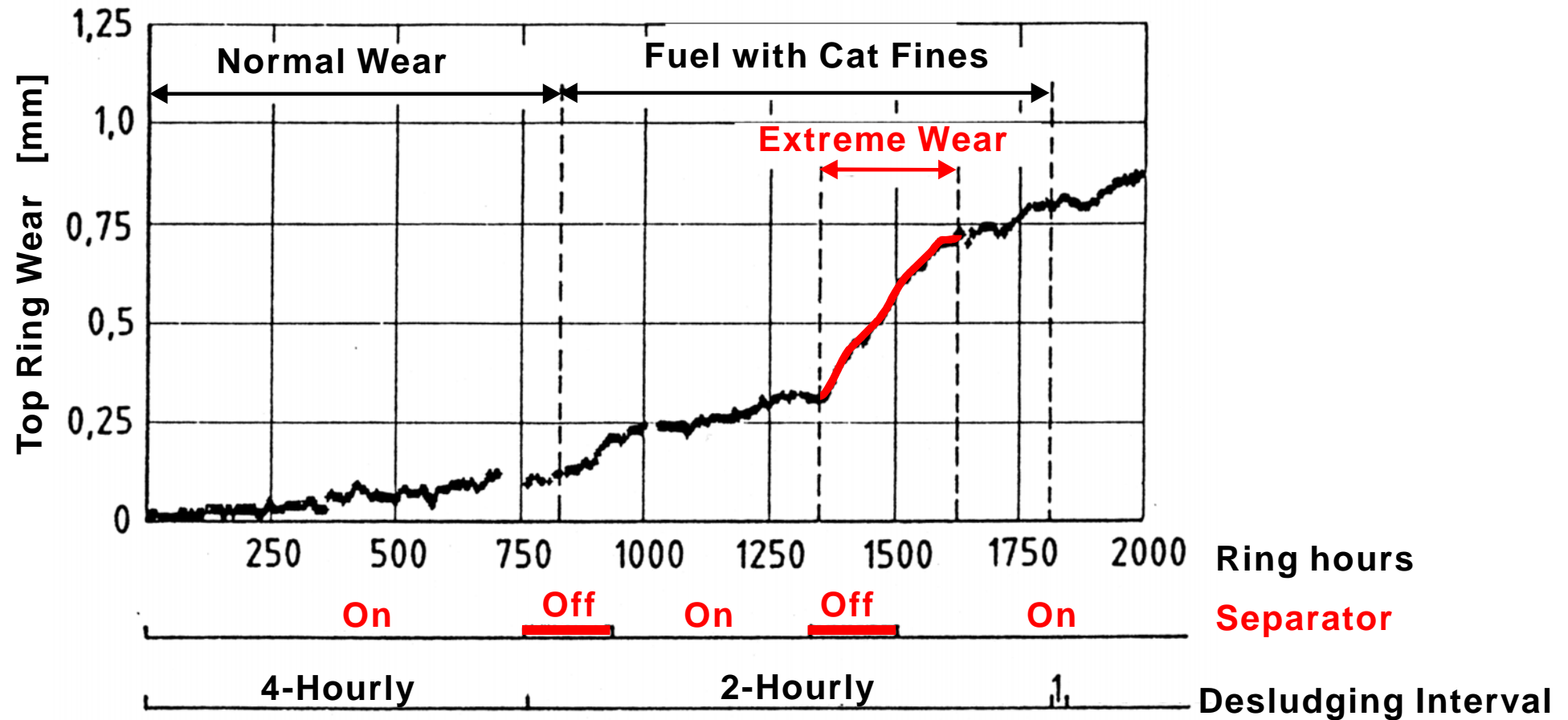
- **Since the 1970s the oil refining changed dramatically.**
- **More conversion processes deteriorated fuel oil quality.**
- **Increasing operational problems led to ISO 8217 in 1987.**



Catalytic Fines



Top Ring Wear of Two-stroke Engine (Cat Fines / Separator Problems)



Actual Heavy Fuel Oil Problems

- Catalyst Fines
- Stability
- Compatibility
- Ignition quality
- Contaminations with waste products



Contaminants in Heavy Fuel Oils

- **Used Lube Oils** (USA / Australia; until 2005)
- **Hydrofluoric Acid** (US ports, 1980s)
- **Organic Chlorides** (Fujairah, 2004)
- **Polypropylene** (Europe/USA, 1990s)
- **Polystyrene** (ARA ports, 2004/2005)
- **Polyethylene** (Singapore, 2004/2005)

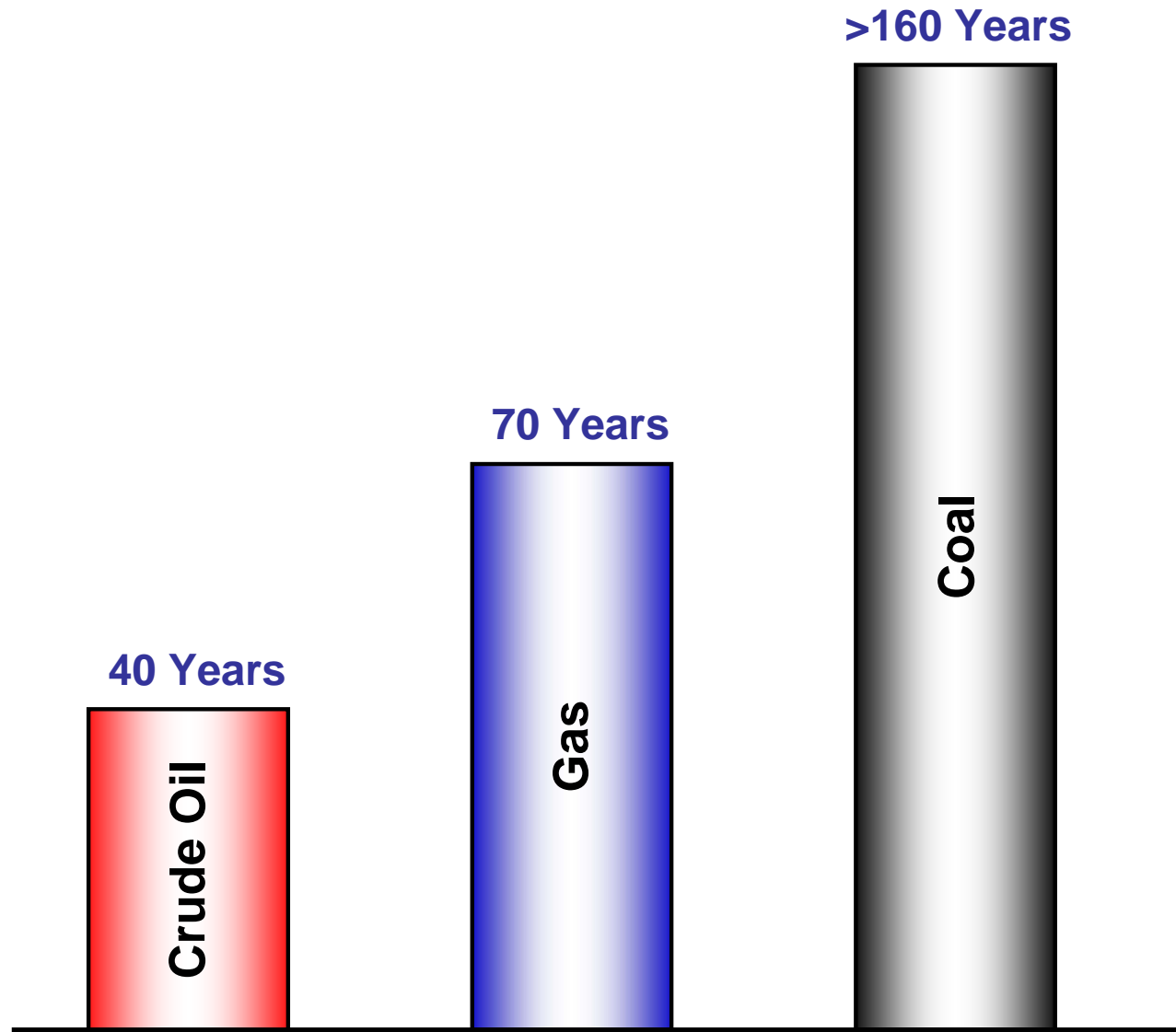


Future Main Problems with Heavy Fuel Oils

- Further deterioration of fuel quality
- Contamination with burnable waste products
- Charterers always purchase the cheapest fuels
- Cost-oriented design of fuel systems
- Increasing compatibility problems due to mixing of different fuel batches (LSO)



Reserves-to-production Ratios



Characteristics of Future Oil Market

- World-wide oil consumption will grow significantly.
- Most of the oil reserves were found in politically unstable countries.
Serious conflicts are most likely.
- Prices of oil products remain on a very high level.



Synthetic fuels from

Tar sands (America)

Oil shale (Canada)

Liquefaction of coal

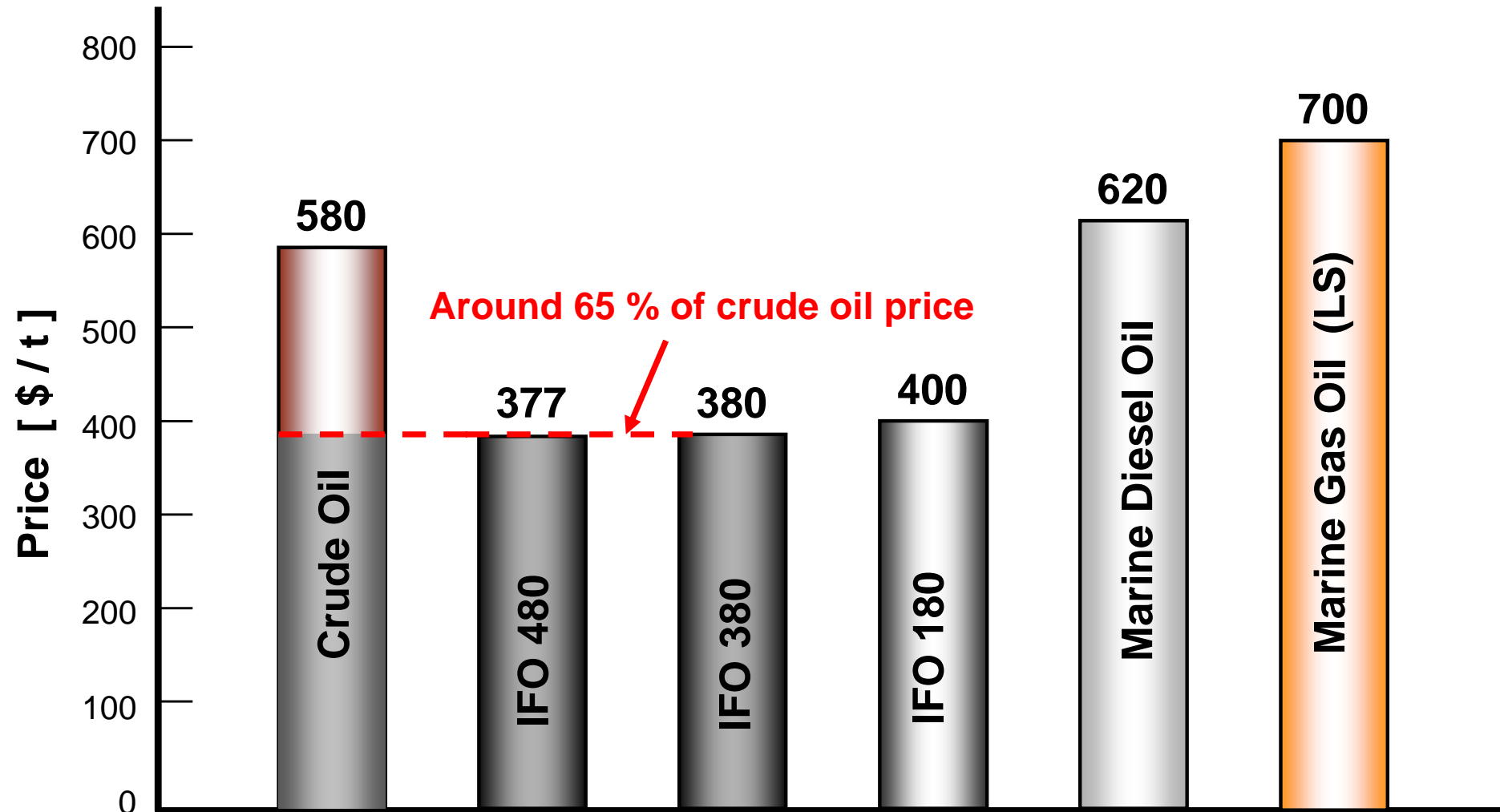


Possible Characteristics of Future Bunker Market

- Harbours and inland waterways: Marine Gas Oil ($S < 0.1\%$)
- Coastal waters: Marine Gas Oil and HFO ($S < 1.0\%$)
Significant extension of SECAs
- On high seas: Heavy Fuel Oils ($S < 2.5\%$??)
- Bunker prices remain on a very high level (Slow steaming ?)
- World-wide substitution of all marine heavy fuels by distillate fuels (Gas oil) is not feasible.



Bunker Prices in Rotterdam (September 2007)



Summary

- Slow and medium speed diesel engines can be adapted to run on various biofuels. Apart from isolated applications biofuels are not a real alternative for marine engines.
- The number of gas engines on gas carriers and ferries will increase.
- In the next 20 years oil products will continue to fuel the marine engines.
- The environmental aspects and the forces of the oil market will influence the bunker market significantly.
- The marine fuel prices will remain on a very high level.
- Occasional technical problems with heavy fuels will keep the experts busy.





SHIP EFFICIENCY

by STG

