Decarbonization Forecast and Fuel Mix

• ABS 2020 Low Carbon Shipping Outlook

• Fuel mix projected to 2050
  - 40% oil-based fuels in 2050
  - 35% ammonia/hydrogen use

• Decarbonization scenarios:
  - The use of low- and zero-carbon fuels will have a significant effect, but it may not be enough to meet the IMO targets
  - Additional measures needed for Accelerated Climate Action
The Three Fuel Pathways of the Future

Light Gas
- LNG
- Bio-/Electro-Methane
- Hydrogen

Heavy Gas
- LPG, MeOH
- Bio-/Electro-Fuels
- Ammonia

Bio/Synthetic
- Bio-/Renewable Diesel
- Gas-to-Liquid Fuels
- 2nd and 3rd generation biodiesel
Production of Hydrogen

- 2019 global production (IEA)
  - 75% from natural gas
  - 23% from coal
- Ammonia can be produced along the way
- US currently produces ~10M ton of H₂ annually
- Can be transported using Liquid Organic Hydrogen Carriers (LOHC)
- If combined with carbon capture and sequestration, hydrocarbon fuels can be produced (e.g. CH₄)
- Hydrogen is significant as marine fuel but also as cargo
  - Hydrogen Council 2050 goals: 18% of worldwide energy demand, 6 Gton of CO₂ reductions annually, $2.5 trillion in annual sales, and 30 million jobs created
  - Global hydrogen industry estimated at $7.5 bn by 2050
Hydrogen can be stored as a gas or liquid:
- Compressed gas at 350-700 bar
- Liquid cryogenic storage at -253°C, 1 bar
- On or within solids

How is hydrogen stored?

**Physical-based**
- Compressed Gas
- Cold/Cryo Compressed
- Liquid H₂

**Material-based**
- Adsorbent
- Liquid organic
- Interstitial hydride
- Complex hydride
- Chemical hydrogen

Source: US DOE
Large reserves of coal and natural gas, but carbon-intensive production – Need regulations that will promote the use of green hydrogen (e.g. lifecycle emissions accounting)

Currently limited production facilities but increasing - Focus on green hydrogen production
Australia: 23 hydrogen production demonstration projects

One Liquified Hydrogen Carrier in existence by KHI
Need for LHC standards and rules
Need rules for alternative power generation systems e.g. fuel cells

Requirement for Hydrogen Liquefaction Systems and advanced storage tanks

Hydrogen Liquefaction System required at bunkering facilities
### Challenges and Opportunities

#### Production
- Fossil fuel conversion
- Biomass and waste conversion
- Electrolysis
- Thermal water splitting
- Biological
- Photochemical
- Direct hydrogen carrier production

#### Distribution
- Hydrogen distribution more challenging than other fuels due to stringent storage requirements (temperature, diffusivity)
- Points to localized hydrogen production stations

#### Bunkering
- Port site facilities currently limited
- Experience gained from LNG bunkering methods, but more stringent requirements posed by hydrogen
Thank you