

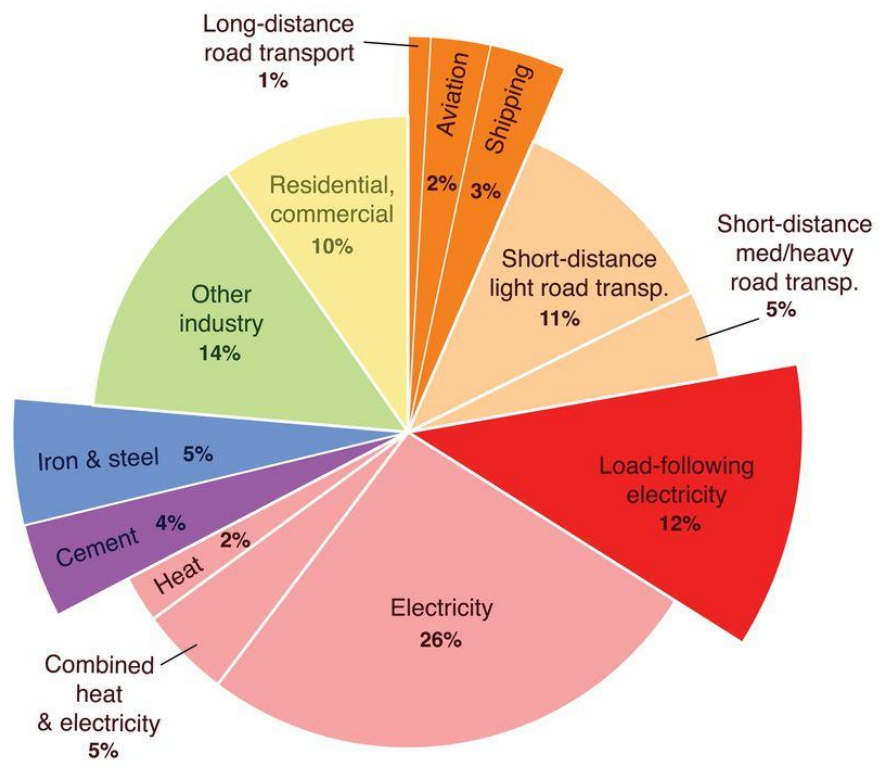
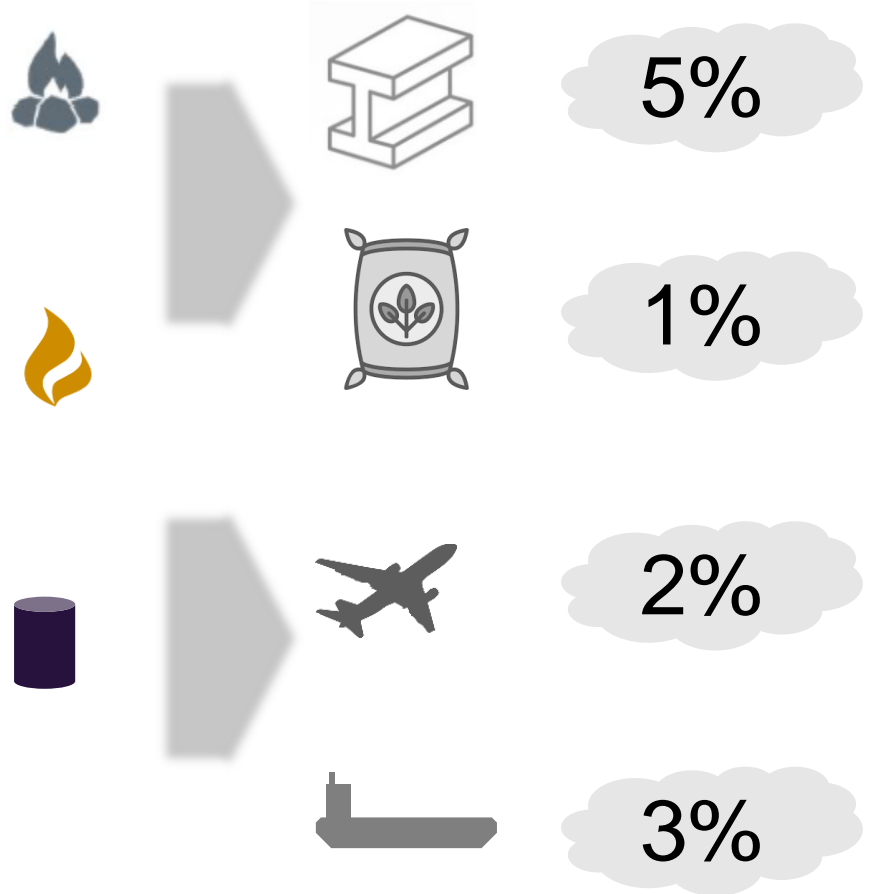


Smart Energy Systems Conference 2019

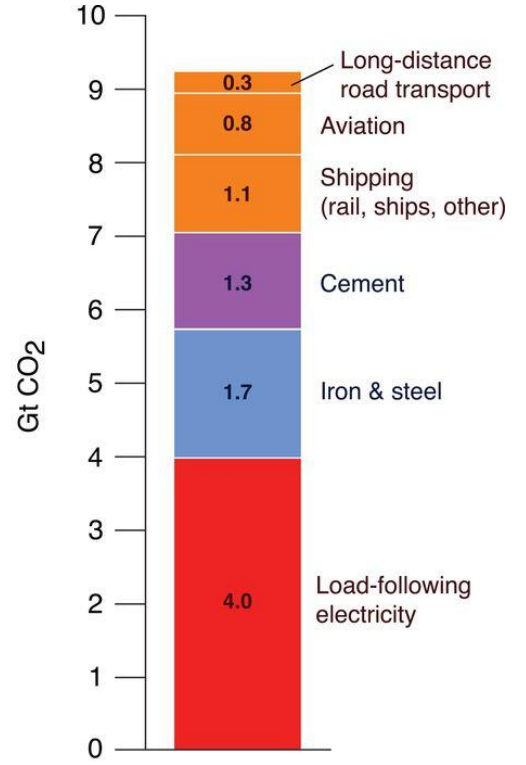
Poul Skjærbæk, Siemens Gamesa Renewable Energy

11. September, 2019

More than 10% of global CO2 emissions come from hard-to-abate sectors, where we need some type of electrofuel to replace the fossil fuel component.



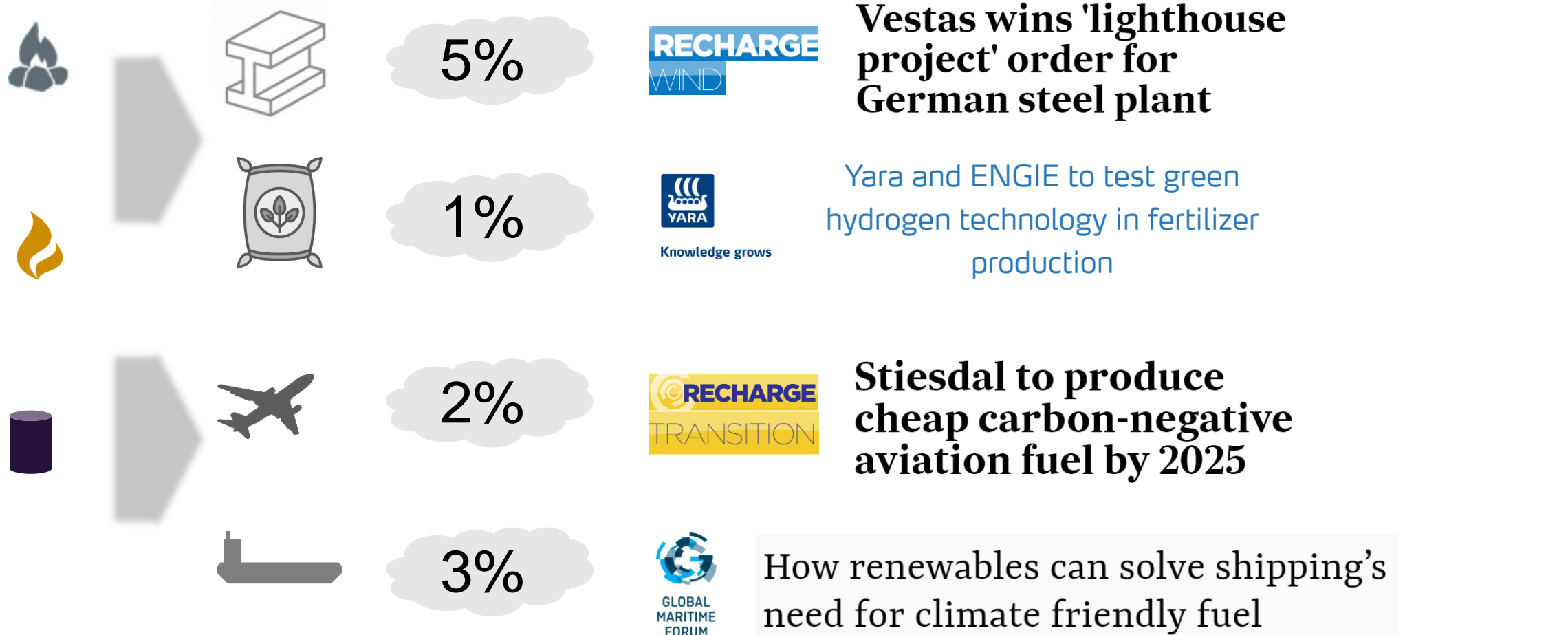
A Global fossil fuel & industry emissions, 2014 (33.9 Gt CO₂)



B Difficult-to-eliminate emissions, 2014 (9.2 Gt CO₂)







Source: Davis et al.: Net-zero emissions energy systems, 2018. Featured in Inside Climate News: These Are the Toughest Emissions to Cut, and a Big Chunk of the Climate Problem, 28.06.2018

Luckily there are several projects underway to utilize electrofuels to decarbonize the Steel, fertilizer, Aviation and Shipping industry.



Sources: Recharge, 26.08.2019, Yara.com, 13.02.2019,, Recharge, 17.06.2019, Global Maritime Forum, 10.05.2019

Application and Market: evaluation of Hydrogen application across major transport applications

Transport type		Predicted end-fuel
Light transport		kWh
Cars		kWh + H ₂
Trucks		kWh + H ₂ + NH ₃ + Biofuels
Trains		kWh
Ships		kWh + NH ₃
Air planes		kWh + Carbon based synthetic fuel (H ₂)

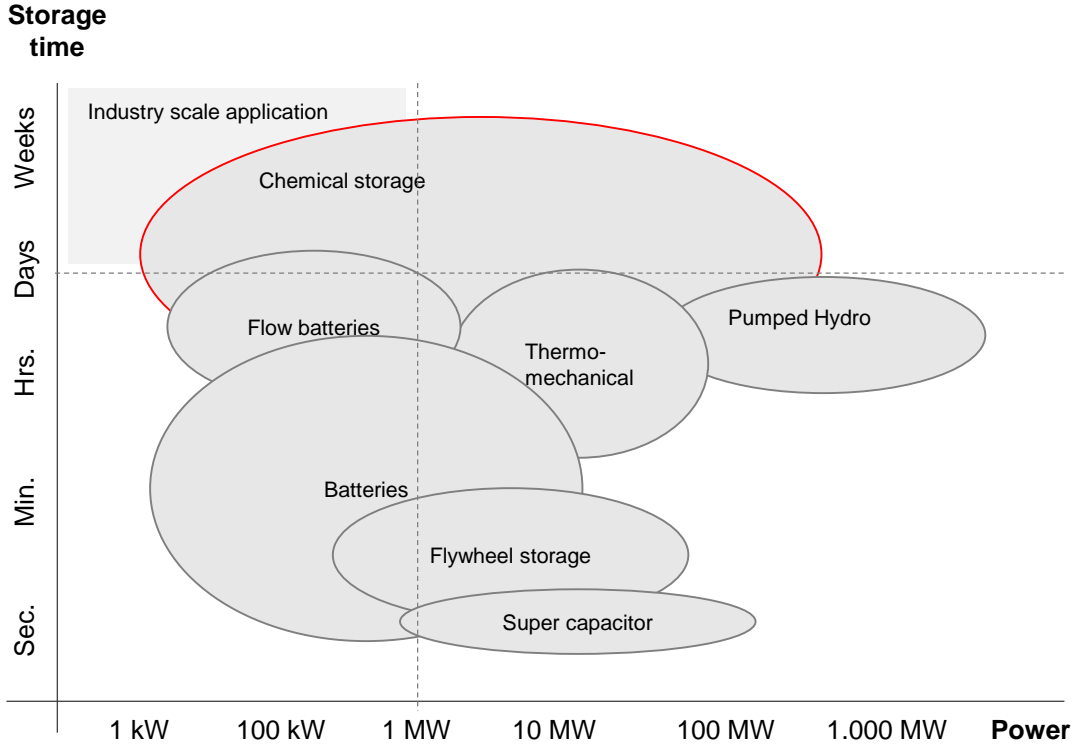
Take out

- Electricity is dominant energy source for light weight transport and short hauls
- Chemicals evaluated dominating energy source for heavy transport, marine transport and longer hauls.
- Hydrogen (H₂) component across dominating chemical fuel types

The **ideal energy-source** to cover future need is a **Renewable hybrid**, producing H₂ and kWh

Shipping: The substitute products all have limitations - breakthroughs are needed

Storage Technology overview

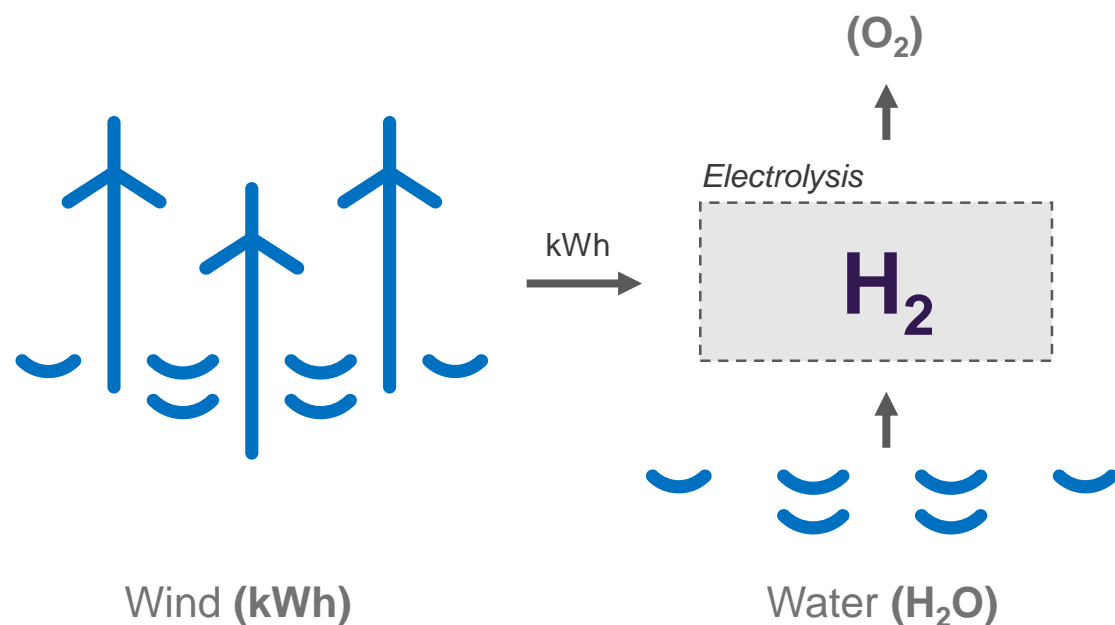


Evaluation of Shipping fuel alternatives

- Batteries**
 - Becomes too heavy. It will only work for short-term ferries.
- Biofuels**
 - Good energy density, but you are using precious farm-land.
- Methanol**
 - Similar energy density to Ammonia, however, requires a carbon source.
- Blue NH₃**
 - Requires Carbon Capture Storage to avoid supply chain emissions.

Why Hydrogen? Conversion technology is proven – however, not in industry scale and in combination with wind turbine technology

Technology



Take-out

- Electrolysis is powered by direct electric current (DC), the outcome is Hydrogen (H_2)
- Hydrogen is used independently as well as in combination with natural gas
- Via the Haber-Bosch technology, Hydrogen can be converted into Ammonia (NH_3)
- Ammonia is widely used as fertilizer and is evaluated a competitive fuel for marine transport

Hydrogen can substitute Gas - Ammonia can substitute Oil

In 2018 the shipping sector (accounting for 2,6% of Worlds CO₂ emissions) agreed to reduce CO₂ emissions by >40% by 2030 targeting 85% by 2050

 **INDEPENDENT** 13.04.2018

Carbon emissions from global shipping to be halved by 2050, says IMO

icct
THE INTERNATIONAL COUNCIL
ON CLEAN TRANSPORTATION

OCTOBER 2017

GREENHOUSE GAS EMISSIONS
FROM GLOBAL SHIPPING, 2013-2015

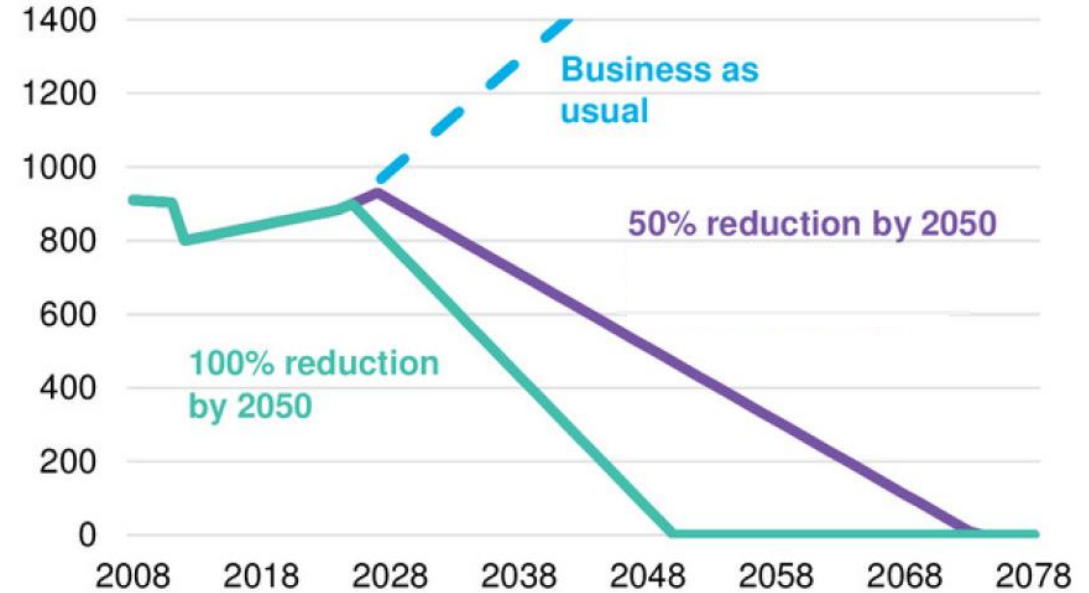
Table 6. Shipping CO₂ emissions compared to global CO₂ emissions, 2007-2015

Source	3rd IMO GHG Study (million tonnes)						ICCT (million tonnes)		
	2007	2008	2009	2010	2011	2012	2013	2014	2015
Global CO ₂ emissions*	31,959	32,133	31,822	33,661	34,726	34,968	35,672	36,084	36,062
International shipping	881	916	858	773	853	805	801	813	812
Domestic shipping	133	139	75	83	110	87	73	78	78
Fishing	86	80	44	58	58	51	36	39	42
Total shipping	1,100	1,135	977	914	1,021	942	910	930	932
% of global	3.5%	3.5%	3.1%	2.7%	2.9%	2.6%	2.5%	2.6%	2.6%

* Global CO₂ estimates include CO₂ from fossil fuel use and industrial processes (EDGAR, 2017).

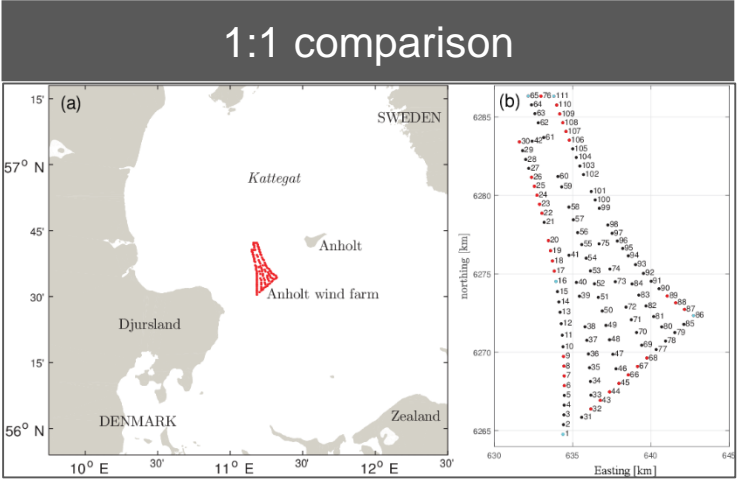
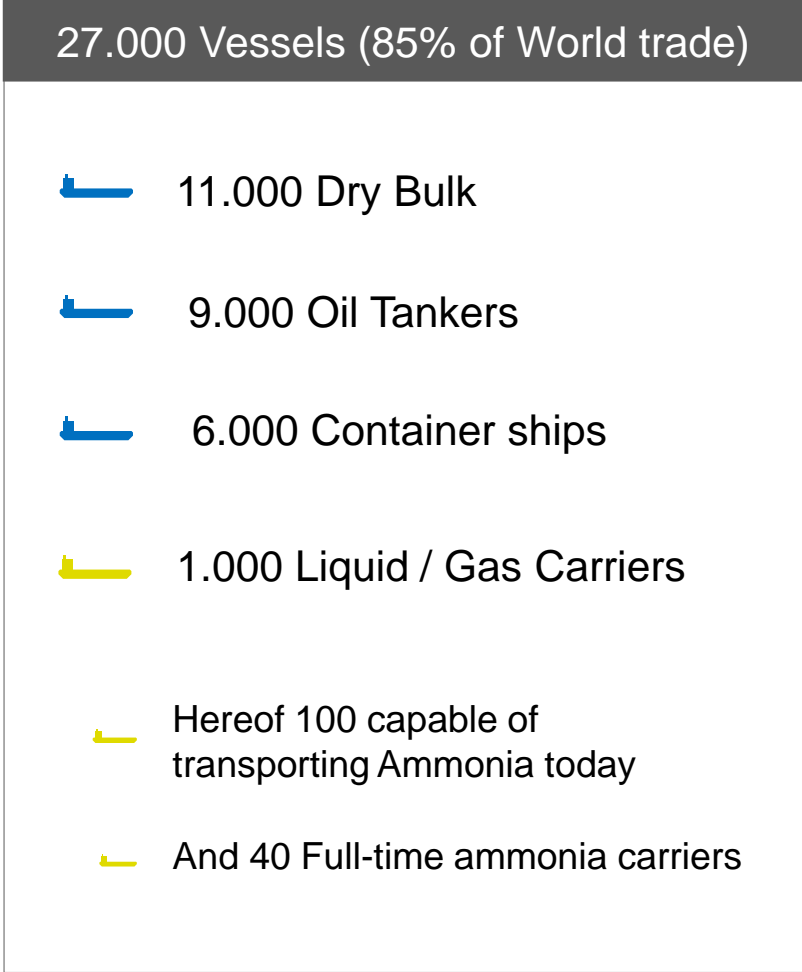
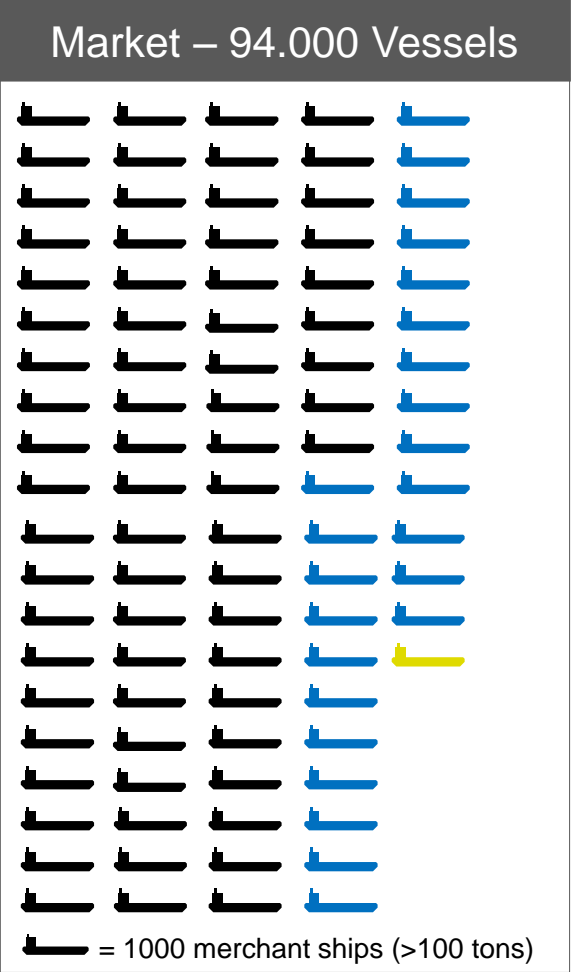
The challenge:

Pathways for international shipping's CO₂ emissions (Mtons):



Source: IMO GHG Strategy, 2018, BloombergNEF

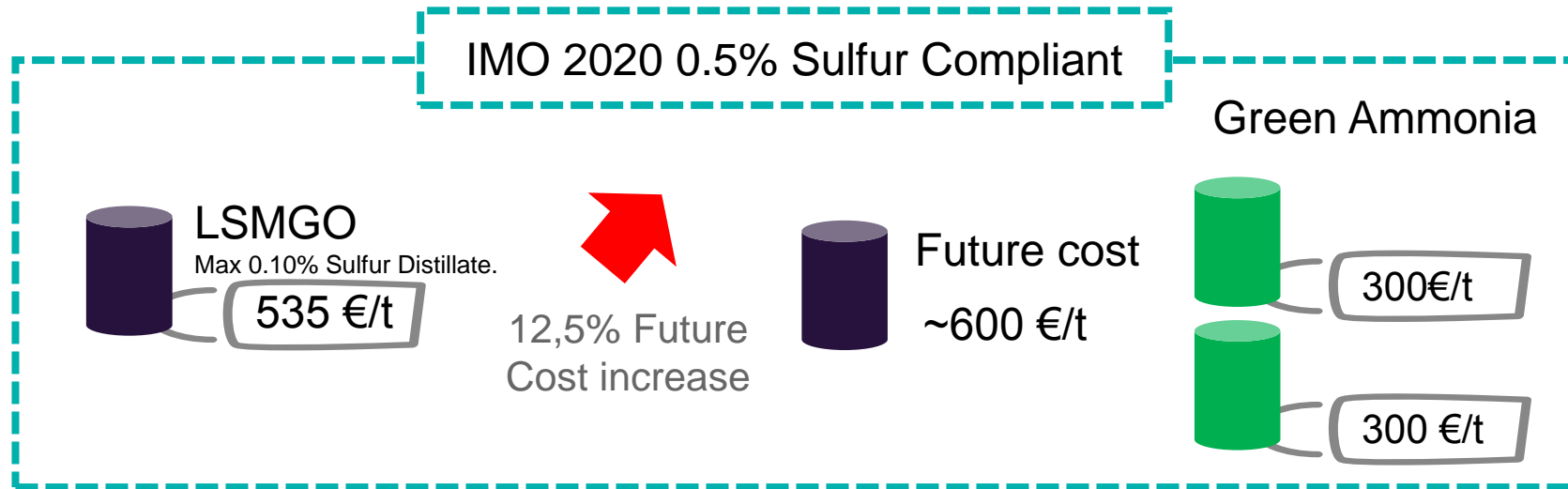
Shipping Market shows significant potential; ~200MW to fuel 1 Triple E vessels



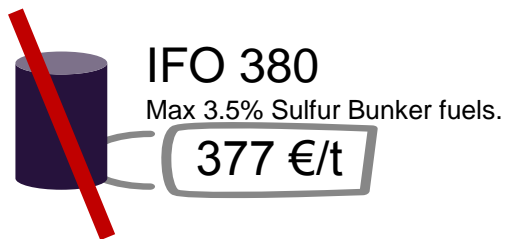
Anholt Offshore: 400MW (111xSWT-3.6-120)



Marine Fuel Oil Price points



Carbon emission are currently not priced: 1 Ton bunker fuel = 3.1 Tons CO2



REUTERS 11.04.2018

Shipping fuel costs to spike 25 percent in 2020 on sulfuric cap: WoodMac

BØRSEN. 16.01.2019
Rederier vil sende mia-regning til kunder



"We expect to pay 200-300 USD extra per ton of fuel, that lives up to these new requirements, and this could equal a doubling of our costs."

Jan Rindbo, CEO - Norden