MARINTEC INNOVATION WEBINAR

DEFINING THE PATH TO DECARBONISATION

1st September 2022

Prof. Dr Martin Stopford
Maritime Economist

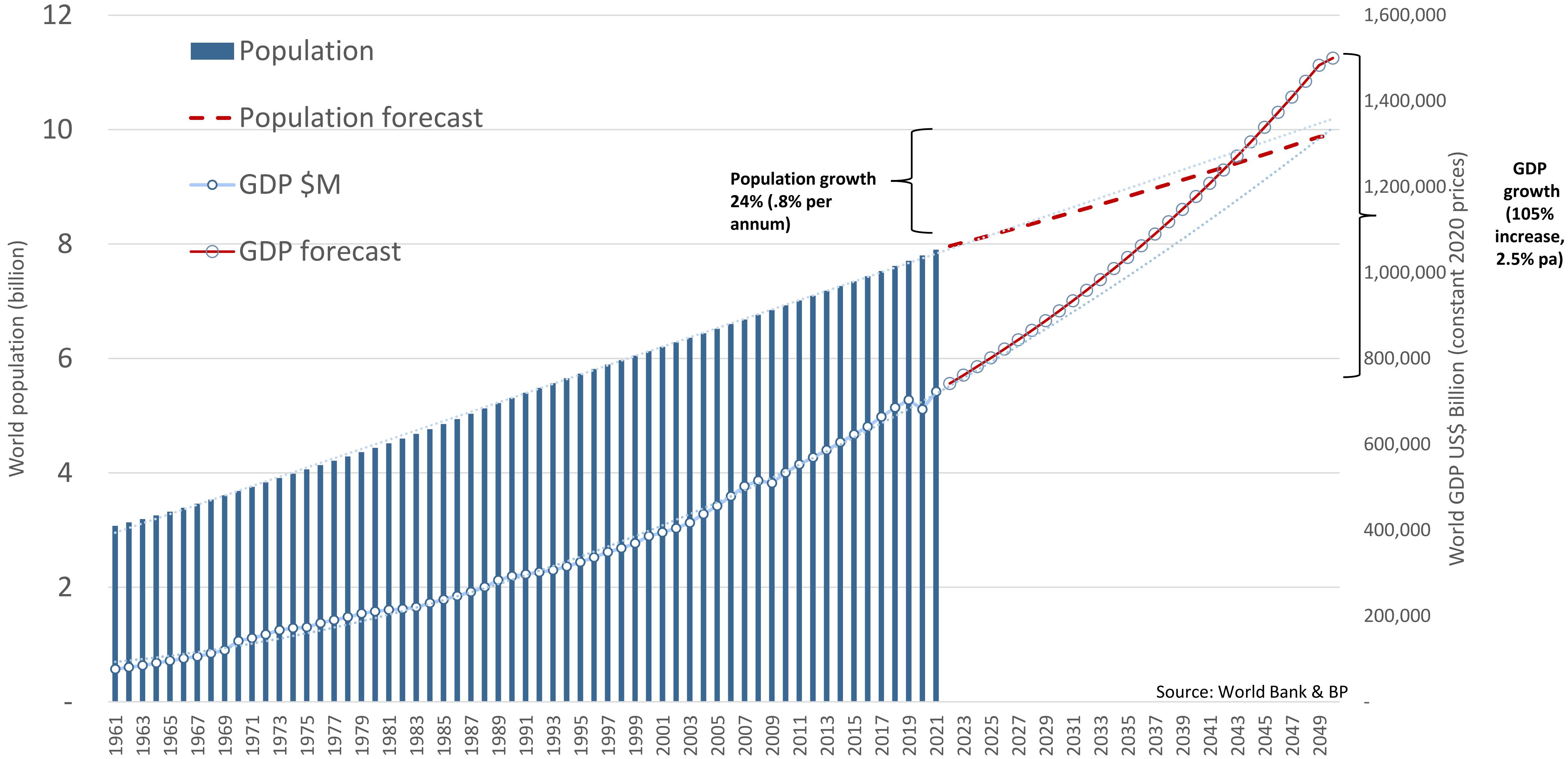
THE AGENDA

1. **The global shipping emissions scenarios 2020-2050**
2. **Technology update: where has the technology got to?**
3. **Deep sea developments**: internal combustion engines & dual fuel
4. **Short Sea and service developments:** hybrid & electric systems
5. **Existing merchant fleet:** complying with EEXI/CII

The starting point is to weigh up the challenge of DECARBONISING sea transport by 2050, as the crisis deepens

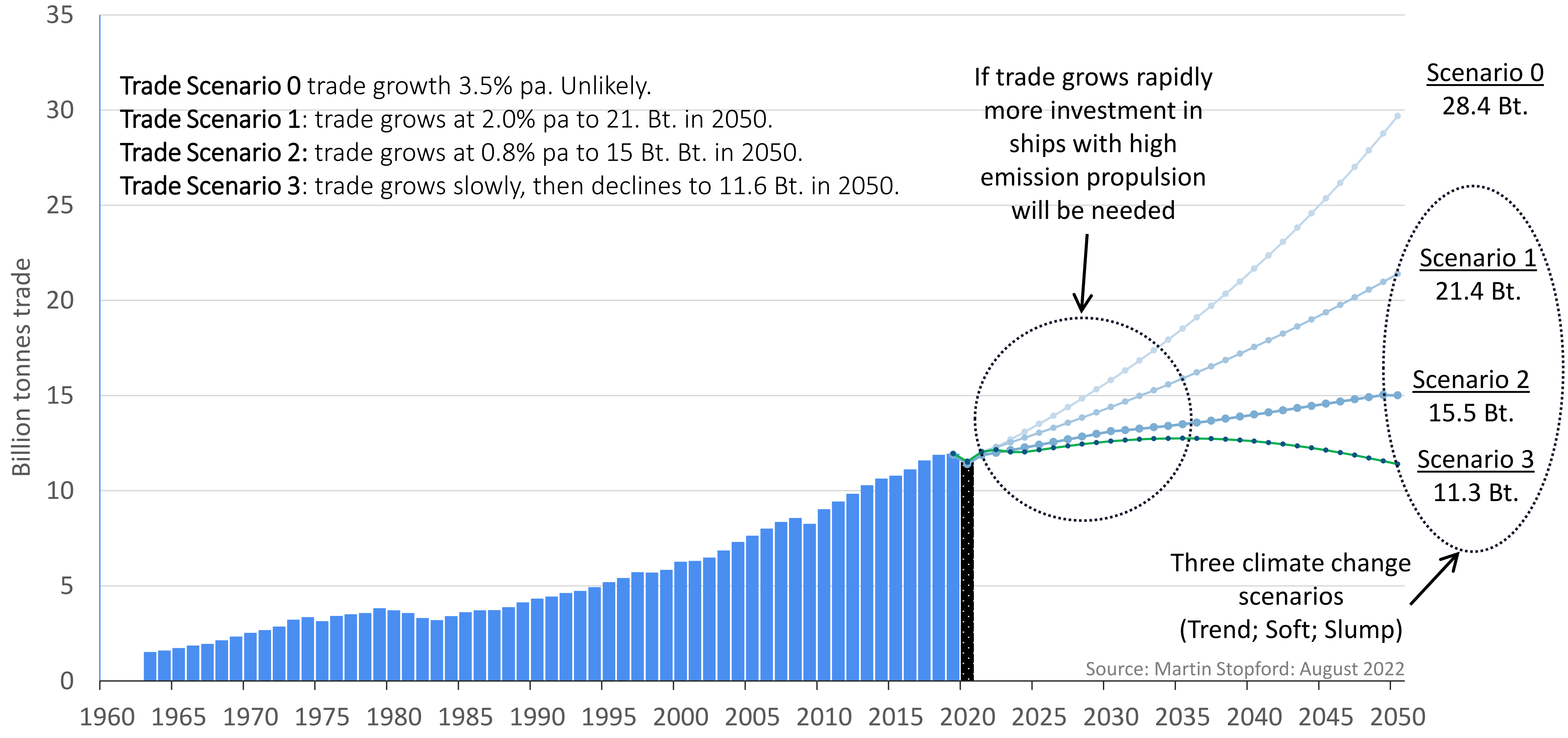
1. THE SHIPPING EMISSIONS SCENARIOS 2020-50.

Growth of GLOBAL population and world GDP mean greater decarb burden

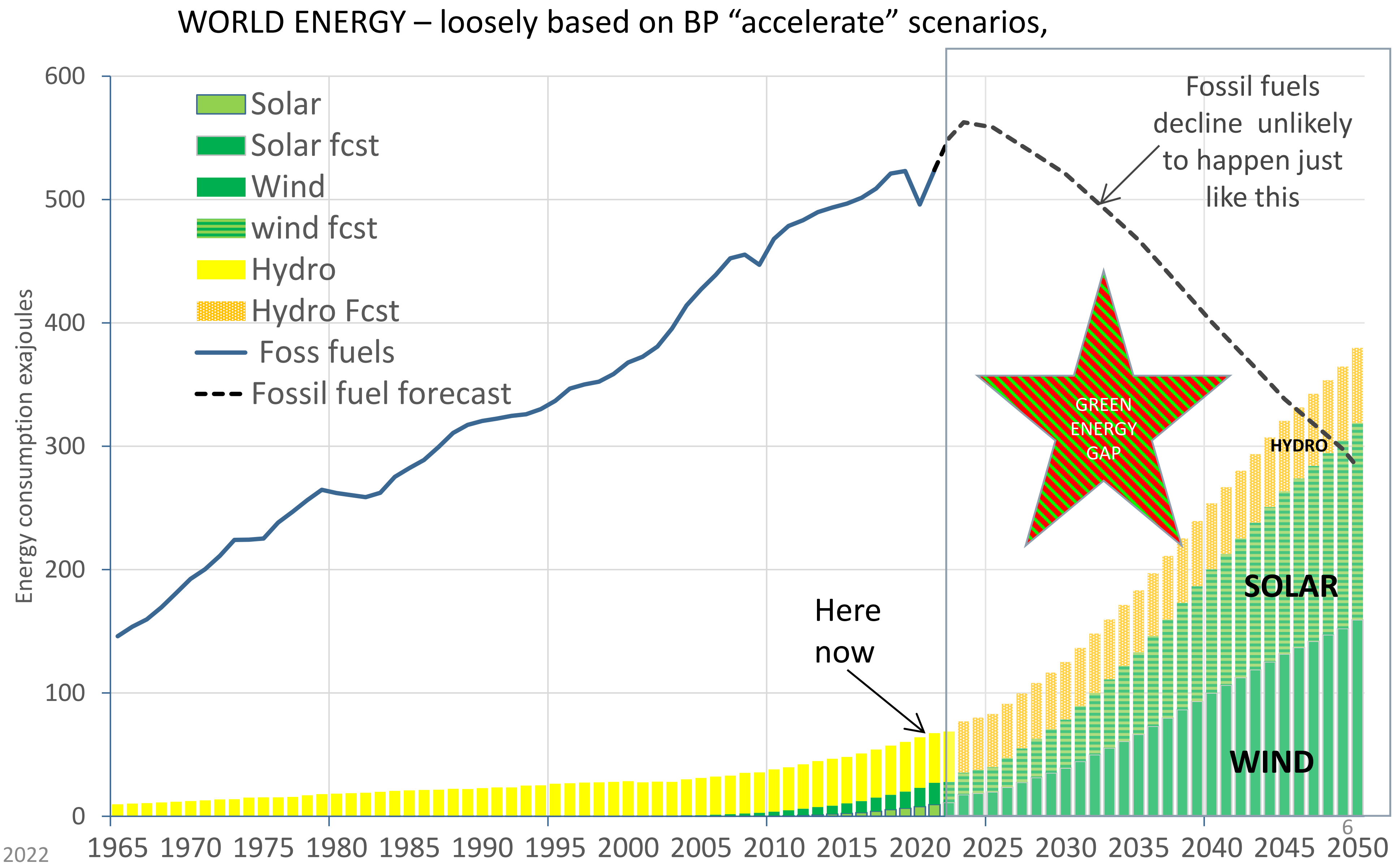


SCENARIOS AUGUST 2022 – revised to reflect progress o pandemic and world economic recovery

The trend: sea trade will follow a different trend – but which one?



Much competition for limited supply of green fuel in 2020s



Fossil fuel and green energy consumption: 1965-2021 and forecasts to 2050

Changing trade structure likely in coming decades

Sea trade by commodity showing actual volumes to 2021 and Trade Scenario 2 for 2020-2050 (revised August 2022)

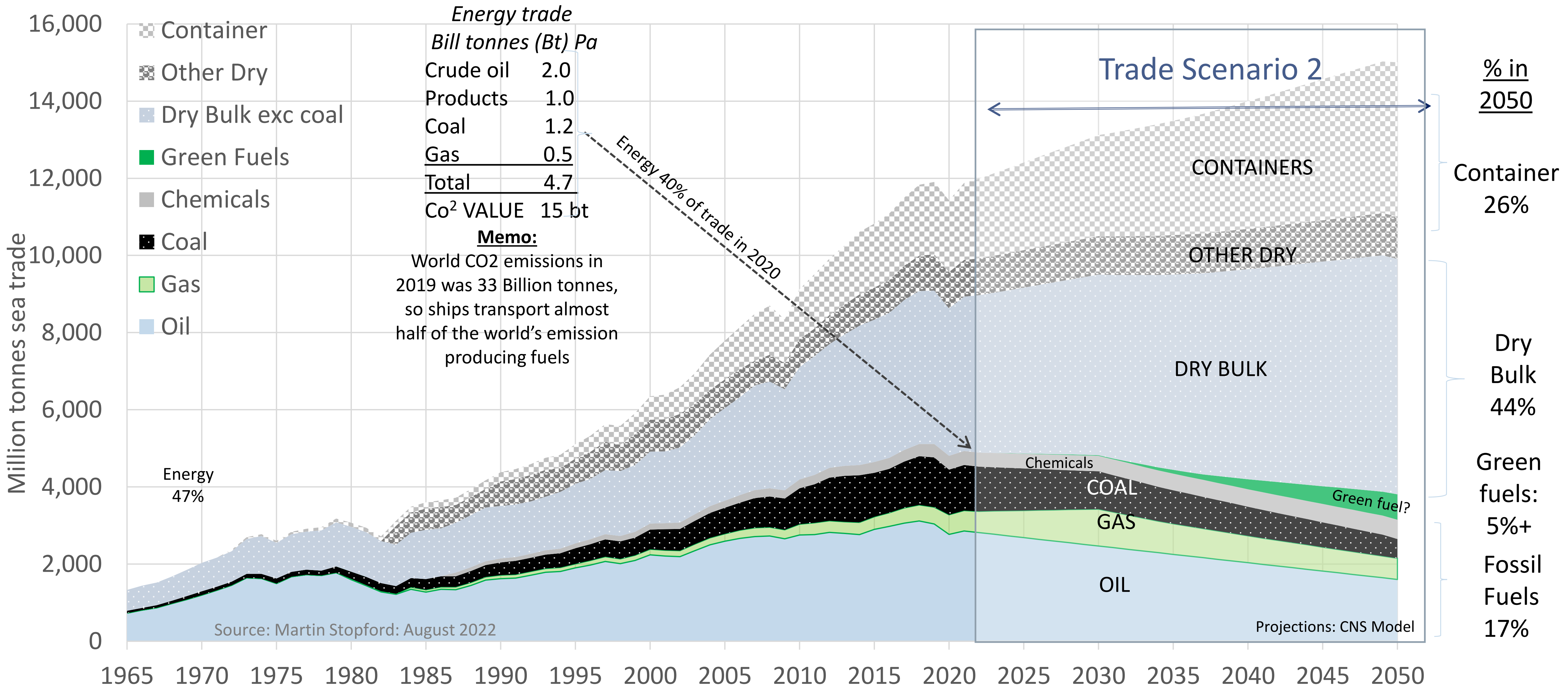
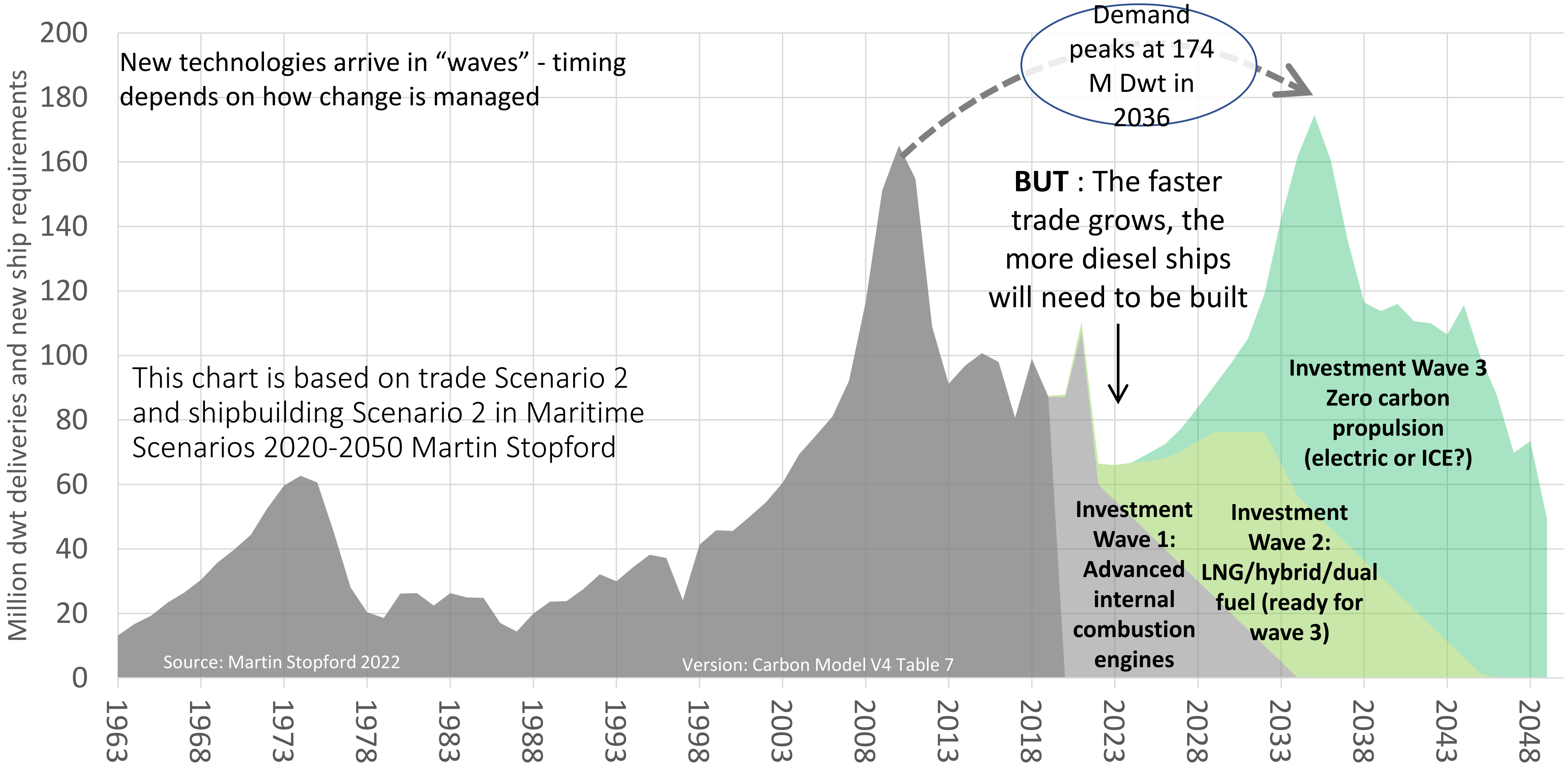


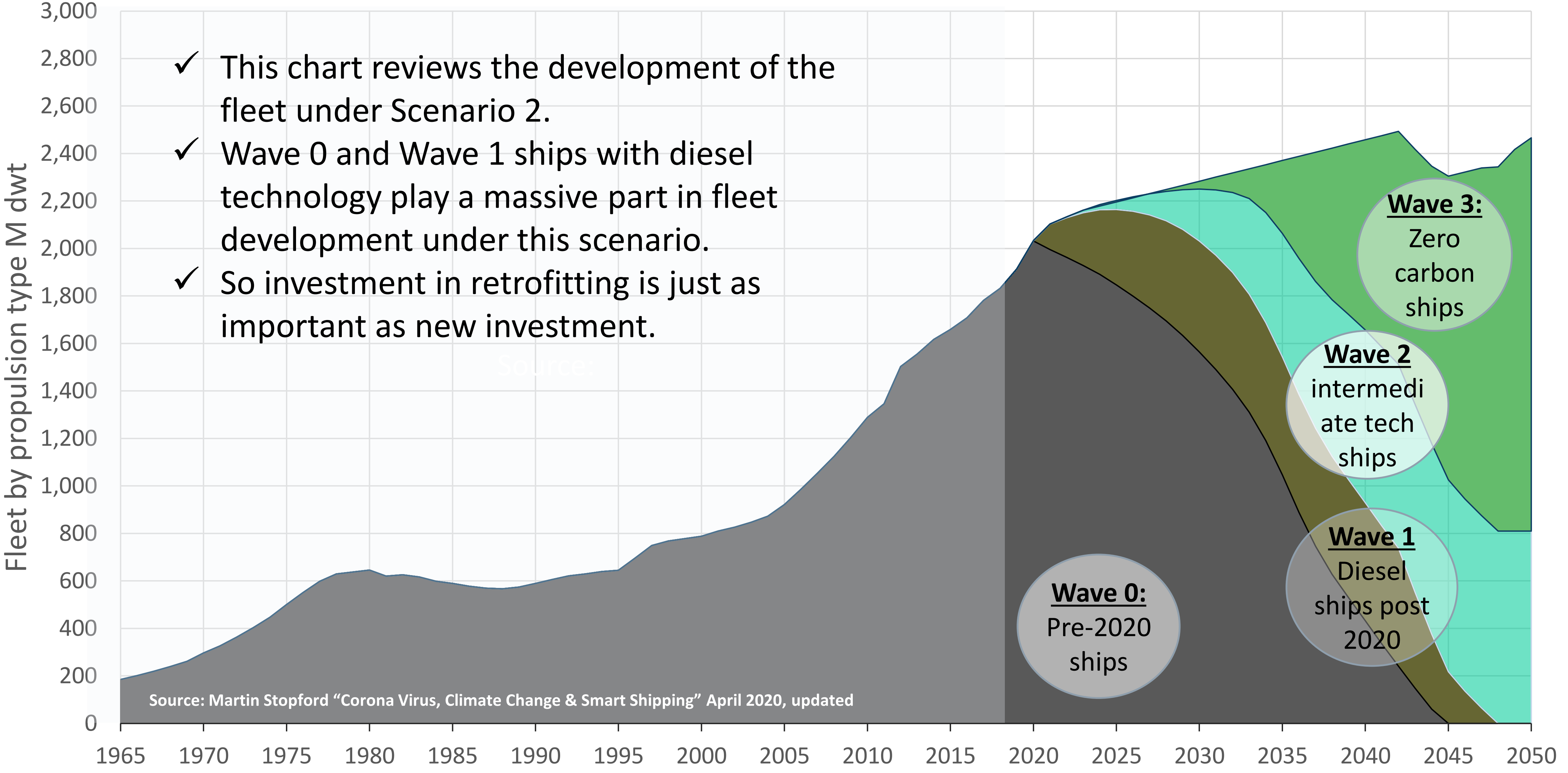
Figure 6: Scenario 2 manages the transition to zero carbon in three waves of investment & shipbuilding deliveries Revised



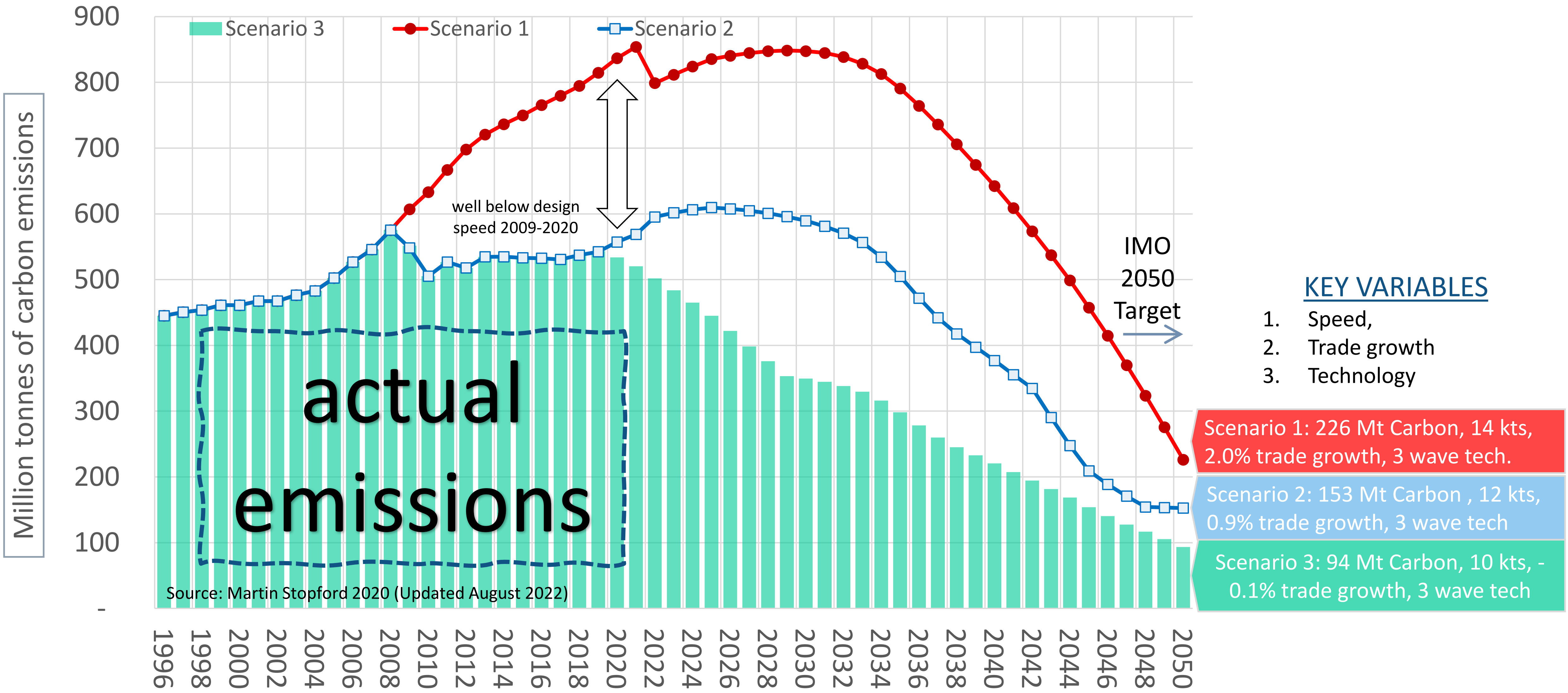
Shipbuilding (Scenario 2): Soft trade growth and 12 knots speed

12. The fleet resulting from the waves of investment (scenario 2)

- ✓ This chart reviews the development of the fleet under Scenario 2.
- ✓ Wave 0 and Wave 1 ships with diesel technology play a massive part in fleet development under this scenario.
- ✓ So investment in retrofitting is just as important as new investment.



World Merchant Fleet: CO_2 emissions scenarios 2021-2050 –



The 3 emissions scenarios –zero carbon ships available

KEY VARIABLES

1. Speed,
2. Trade growth
3. Technology

2. TECHNOLOGY UPDATE – HARDWARE STRATEGY CLEAR, BUT GETTING PEOPLE TO MANAGE THE DETAIL IS CHALLENGING

1. Production methods for dual fuel ships with clean bunkers (hydrogen, methanol, ammonia, nuclear reactors) now well defined. We need to get started!
2. Electric propulsion presents development opportunities over shorter distances. Battery costs falling. Research for 2030s green propulsion high priority too.
3. Digital information systems and artificial intelligence, developing well, and just as important as the propulsion system.
4. People needed to manage transition

Investment not easy - many technologies and uncertain costs make decisions complex: -

1. GREEN FUEL

1. **"Cleaner" fossil fuels**: - e.g. LNG, LPG (limited)
2. **Biofuels; (**limited)
3. **Green electricity from**: -
   1. Solar panels
   2. Wind turbines
   3. Nuclear reactors.
   4. Batteries

4. FUEL from green electricity: -

a) Hydrogen
b) Methanol
c) Ammonia
d) Batteries

5. Carbon capture *(CCS):*

2. PROPULSION SYSTEMS

I. Internal Combustion engine with shaft drive

II. Electric motor/s with: -

- Diesel-generators
- Battery, fuel cell
- Hybrid , ICE

3. SHIP DESIGN "TUNING"

1. Fuel "combustion" loss 51%

a) Waste heat recovery
b) Battery - hybrid
c) Power optimization
d) Advanced maintenance
e) Tune management (AI)

2. Transmission loss 21 % Fuel

a) Propeller speed & size
b) Propeller design/condition
c) Wake equalizer
d) Pre-swirl (e.g. Mewis duct)
e) New propulsor e.g. flipper

3. Wave making 13%

a) Speed
b) Hull design,/dimensions

4. Hull design 15%

a) Block coefficient,
b) Hull condition
c) Air lubrication
d) Ballast design
e) Lighter structure

4. OPERATIONAL "TUNING"

1. Operations

a) Cargo size.
b) Voyage plan: -

- Passage management
- Ballast management
- Trim management
- Dead freight
- Port operations
- Off hire plan

2. Service & ballast speed

$$\text{E6(4)} \quad F = F^* \left(\frac{S}{S^*}\right)^a$$

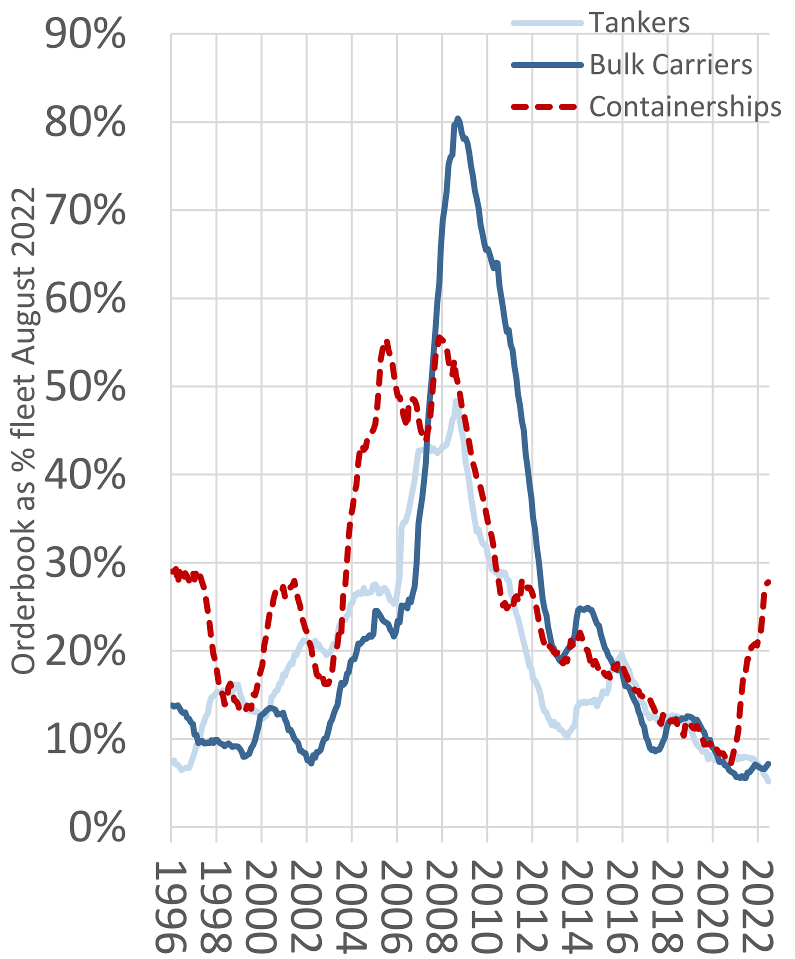
where:
F = actual fuel (tons/day)
S= actual speed
F*= design fuel (tons/day)
S*= design speed

2. DEEP SEA DEVELOPMENTS

New ship investment focusing on dual fuel diesel engines. Regulations, & technical obsolescence major issues

Investment trends - orderbook as % fleet

- Containers investing heavily,
- Dry bulk and tanker investment is very low, despite firm markets.
- Dual fuel LNG orders in specialist sectors & some Methanol
- Dual fuel ammonia engines start delivery 2024.
- Limited bunkering availability except for LNG



REFINEMENT ENGINEERING IN DEEP SEA SHIPS:

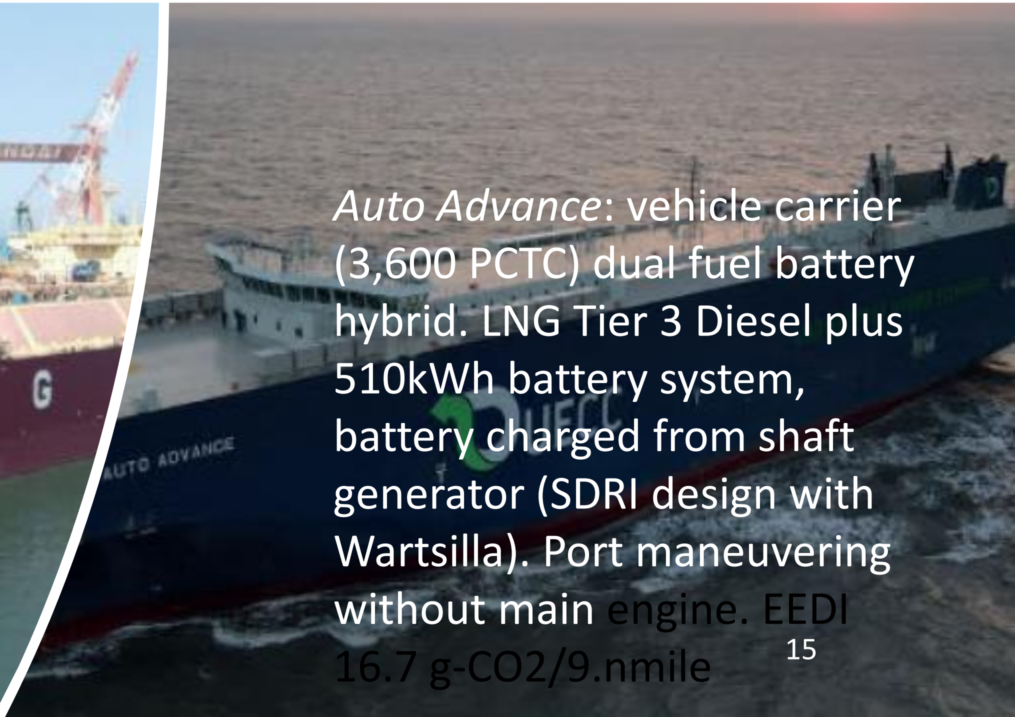
There are many ways of improving the efficiency of deep-sea ships.

- **Real time digtal monitoring of oil/energy use.**
- **Big, shallow draft ship (if you can fill it).**
- **Burning cargo boil off.**
- **Battery support for port entry and electric load management.**
- **Dual fuel engines.**

Cape Ace: 101 000 dwt bulker has integrated flow meters on main engine, auxiliaries, auxiliary boiler, MDO/MGO, feed water, cylinder oil. Has 12.9 m draft & wide beam.

HL Eco: bulker, 159,000 dwt, MGO/LNG dual fuel, EEDI 2.51.

Prism courage: LNG tanker running entirely on boil off.



Auto Advance: vehicle carrier (3,600 PCTC) dual fuel battery hybrid. LNG Tier 3 Diesel plus 510kWh battery system, battery charged from shaft generator (SDRI design with Wartsilla). Port maneuvering without main engine. EEDI 16.7 g-CO2/9.nmile

Electric propulsion viable over shorter distances.

Growing investment interest in battery and hybrid electric designs (E ship, hybrids etc.).

3. SHORT SEA & SERVICE DEVELOPMENTS

Short sea cargo and service ships developing using battery and hybrid designs.

- *Altera wave*: - shuttle tanker, 4x MS engines, LNG/collected VOCs/ MDO (backup). Battery surge support for on board electrical supply (2x1.8 kWh units)
- *Bjorg Pauline*. Hybrid LNG and battery fish carrier (Has battery support for on board systems, chargeable on shore (Tersan)
- *Hydrobingo* – diesel & hydrogen
- *Yara Birkeland* – all electric containership

Challenge to "plug the gap" until carbon-efficient ships become commercially available.

Need to comply with EEXI & CII on Jan1st, 2023?

4. THE EXISTING MERCHANT FLEET

Implementing the CII (carbon intensity indicator)

Measured in grams of CO_2 emitted per unit of transport capacity (or cargo carried), per nautical mile*

$$CII_t = \frac{FUEL\ CONSUMPTION_t \times CO2\ FACTOR_t}{TRANSPORT\ WORK_t} \times CORRECTION\ FACTOR_t$$

(Being developed)

On or before 1 January 2023, all ships above 5,000 GT need to have an approved enhanced Ship Energy Efficiency Management Plan (SEEMP), including an implementation plan on how to achieve their CII targets.

The intention of CII, an enhanced SEEMP, is to ensure continuous improvement, and its implementation will be subject to company audits.

IMO Ship Fuel Oil Consumption Database (DCS data) has been launched as a new module within the Global Integrated Shipping Information System (GISIS) platform and that Member States now have access to the Database.

The yearly CII is calculated based on reported IMO Data Collection System (DCS) data, and the ship is given a rating from A to E. For ships that achieve a D rating for three consecutive years or an E rating in a single year, a corrective action plan needs to be developed as part of the SEEMP and approved.

A vessel can reduce its carbon intensity by a combination of measures: -

-Speed reduction

-Optimization of operations & logistics

-Implementation of energy efficiency technologies

-Use of alternative fuels

*(e.g. 15.6 g-CO2/t.nmile)

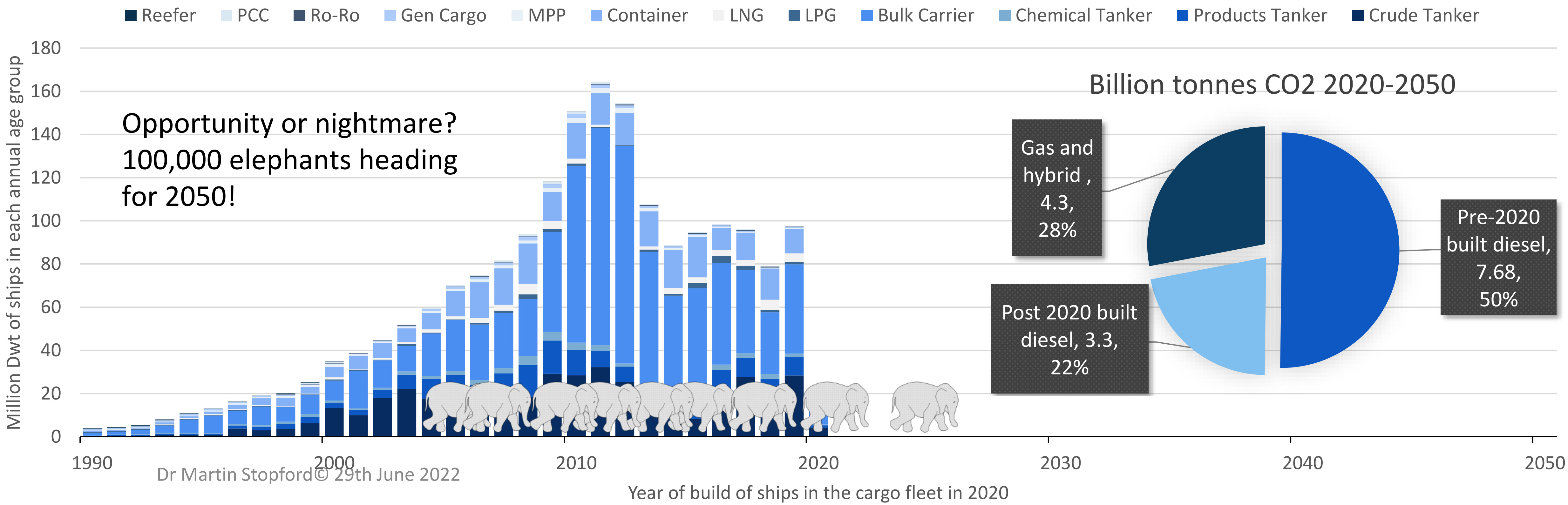


Figure 2: Age profile of the world merchant fleet by vessel type – retrofitting it is the elephant in the room

The fleet is owned by about 24,000 companies, many with very limited resources and a strategy of strict cost-minimization

<u>CHALLENGES</u>

1. Existing fleet will generate half the emissions 2020-2050
2. On Board Electrical & Control Systems
3. Making Information & AI Work
4. Strategy For Organisation, Cooperation, Personnel & Training in small companies

Table 16.2 Company fleets by ship type — Gross Tonnes (GT)

Ship Type Sector	Company Fleet analysis (number)			Fleet Characterisitics	
	Companies in sector	Av. ships per company	Total ships in sector	Total fleet in sector M GT	Av ship size GT
1 Bulker	263	15.4	4,058	174.3	42,940
2 Capesize Bulker	62	12.3	760	65.6	86,352
3 Panamax Bulker	161	7.2	1,165	52.3	44,859
4 Handymax Bulker	274	7.3	2,001	66.9	33,417
5 Handysize Bulker	281	6.8	1,906	37.4	19,616
Total bulk carriers	1,041	9.5	9,890	396.4	40,080
7 Crude/Products Tanker	281	14.0	3,933	233.2	59,291
8 Tanker	116	9.2	1,065	28.9	27,093
9 Sub 10K Tanker	942	4.8	4,565	15.3	3,348
10 Chemical	100	9.5	945	13.9	14,737
Total tanker fleet	1,439	7.3	10,508	291.3	27,717
11 Container	31	45.7	1,418	78.6	55,449
12 Containership <3,000 TEU	187	10.2	1,910	31.3	16,407
13 Containership 3,000-7,999 TEU	36	15.1	544	33.7	61,962
14 Containership 8,000+ TEU	16	33.7	539	49.0	90,944
15 General Cargo	2,305	4.9	11,204	41.6	3,712
Total general cargo fleet	2,575	6.1	15,615	234.3	15,003
16 Gas Carrier	3	29.0	87	5.0	56,944
17 LNG	42	7.6	319	32.4	101,647
18 LPG	125	8.1	1,013	14.4	14,217
19 Cruise	51	6.4	328	19.3	58,948
19 Ferry	779	5.5	4,321	14.0	3,248
20 Ro-Ro	90	5.9	530	10.5	19,796
21 Vehicle Carrier	35	12.2	428	19.9	46,551
22 Reefer	177	4.1	719	3.2	4,410
23 Diverse	1,201	6.2	7,400	128.0	17,298
23 Specialised	2	5.0	10	0.2	24,087
Total specialised fleet	2,505	6.0	15,155	247.0	16,298
24 Offshore	510	6.8	3,482	8.1	2,336
25 Offshore Construction	90	5.9	528	7.5	14,269
26 Offshore Drilling	21	5.0	106	5.7	54,163
27 Offshore Logistics	5	3.2	16	1.8	114,182
28 Offshore Production	25	5.1	127	13.2	103,652
29 Offshore Supply	385	12.7	4,903	11.0	2,236
30 Offshore Survey	92	4.1	375	1.2	3,186
31 Other	146	4.7	688	1.0	1,456
32 Tug	2,066	7.2	14,891	12.3	825
Total non-cargo fleet	3,340	7.5	25,116	61.8	2,463
33 Companies with more than 1 ship	10,900	7.0	76,284	1230.8	16,134
34 Trading companies with 1 ship	13,633	1.0	13,584	45.3	3,337
Total merchant fleet	24,533	3.5	86,174	1,230.8	14,282

Source: Analysis by Martin Stopford based on Clarkson Research "World Fleet Register" 2017

Retrofitting

- Retrofitting is time consuming to set up and labour intensive to implement. But it is the only way forward for existing ships that will otherwise generate about half the carbon emissions in the next 28 years

Area of Performance Improvement	System example
Cooling water heat loss	Optisave
Boiler waste heat recovery	
Real time readings from on board systems	Blueflow
Energy efficient lighting	
Lube oil filtration	
Data sharing platform to manage performance	DNV: Veracity System
Exhaust gas bypass for low load tuning	
Shore Power	
Trim optimisation	
Turbo charger upgrade	
Prop & rudder optimisation	Promas
Anti-fouling - robotic hull clean on berth	Robot hull clean
Electronic fuel monitoring	Roysten
Ballast water management system	
Energy efficient lighting	LED units
Lube oil filtration energy management	
Air lubrication	
Power take-off	
Ship energy optimisation system	
Identify fuel saving, calculate best speed & trim	Greensteam "Discovert"
New bulbous bow matched to steaming speed	

Source: The Retrofit Project – Green Ship of the Future 2020

THE END

Dr Martin Stopford,

MarEcon Ltd

23rd August 2022