

Addressing the Challenges and Business Opportunities in Implementing Maritime 2050

Meeting the Environmental Challenge

Susan Gourvenec

Royal Academy of Engineering Chair in Emerging Technologies, Intelligent & Resilient Ocean Engineering

Deputy Director, Southampton Marine & Maritime Institute

Professor of Offshore Geotechnical Engineering

University of Southampton, UK

MARITIME 2050

The Environmental Challenge



Maritime 2050 values and ambitions

Maritime 2050 Strategic Ambitions

The UK will...

- Maximise our strength in maritime professional services, retaining and enhancing our **UK competitive advantage** in the provision of maritime law, finance, insurance, management and brokering, and developing our green finance offer.
- Lead the way in taking action on **clean maritime growth** enjoying economic benefits from being an early adopter or fast mover.
- Strengthen our reputation for maritime innovation, maximising benefits to the UK from new **maritime technology** through our world leading universities, maritime small and medium enterprises (SMEs) and global companies.
- Continue to be recognised as the global leader in **maritime safety and security** standards and expertise worldwide.

7 themes:

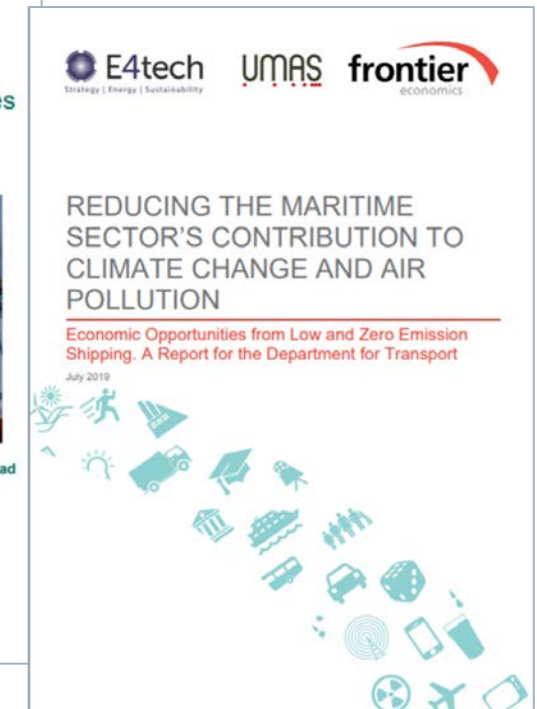
- UK competitive advantage
- technology
- people
- **environment**
- infrastructure
- trade
- security

CLEAN MARITIME PLAN

Environment Route Map for Maritime 2050



“The plan reflects the need to respond to the challenges of climate change and air pollution’s threat to public health, and identifies the clean growth opportunities associated with a transition to zero emission shipping.”



MARITIME AIR POLLUTION

Scale – taking CO₂ as example

- Global CO₂ emissions = 37 Gt/an
- 8 – 10Gt increase in CO₂/an
- 15 Gt/an from stationary sources
- Global shipping emits 940 Mt CO₂/an
= 2.5% of global emissions

If global shipping were a country it would be 6th largest emitter in the world



Country	Total Emissions	2015
China	9.04 Bn	
United States	5.00 Bn	
India	2.07 Bn	
Russia	1.47 Bn	
Japan	1.14 Bn	
Germany	729.77 Mn	
South Korea	585.99 Mn	
Iran	552.40 Mn	
Canada	549.23 Mn	
Saudi Arabia	531.46 Mn	

<http://worldpopulationreview.com/countries/co2-emissions-by-country/>

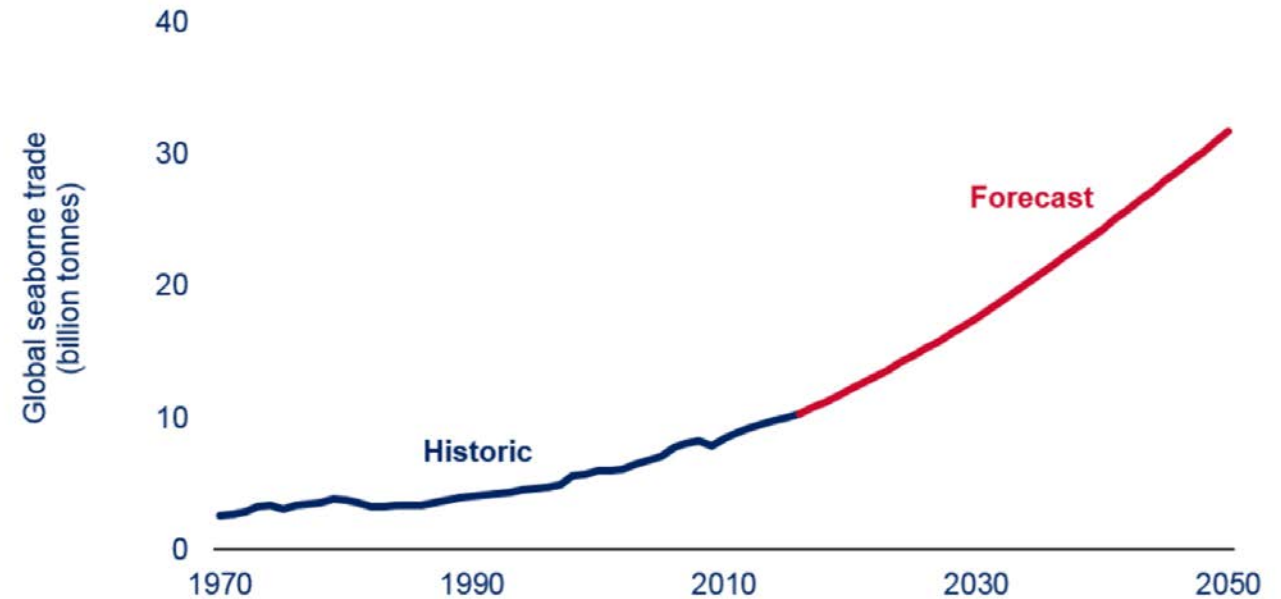
<http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Greenhouse-Gas-Studies-2014.aspx>

MARITIME AIR POLLUTION

International imperative

- Forecast increase in global shipping
- Business as usual not an option
- 2018 IMO commitment to:

“reduce the total annual GHG emissions by at least 50% by 2050 compared to 2008, while, at the same time, pursuing efforts towards phasing them out entirely.”



Source: UNCTAD, OECD, DfT Calculations

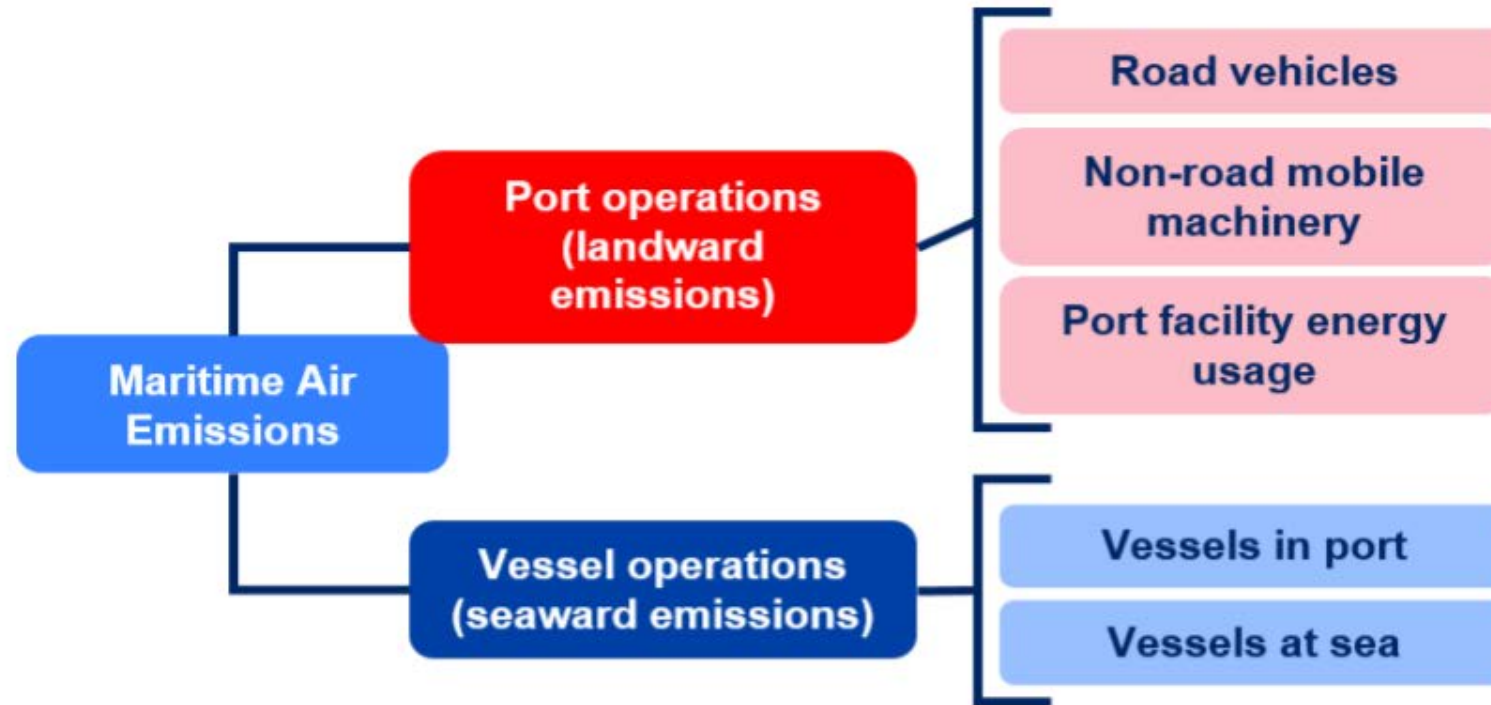
Figure 2 - Projections of global seaborne trade

<https://www.gov.uk/government/publications/maritime-2050-navigating-the-future>

<http://www.imo.org/en/MediaCentre/PressBriefings/Pages/06GHGinitialstrategy.aspx>

MARITIME AIR POLLUTION

Sources



Variety of pollution - CO₂, other GHGs, SO_x, NO_x, particulates ...

Figure 14 - Sources of maritime air pollution

MARITIME AIR POLLUTION

Sources

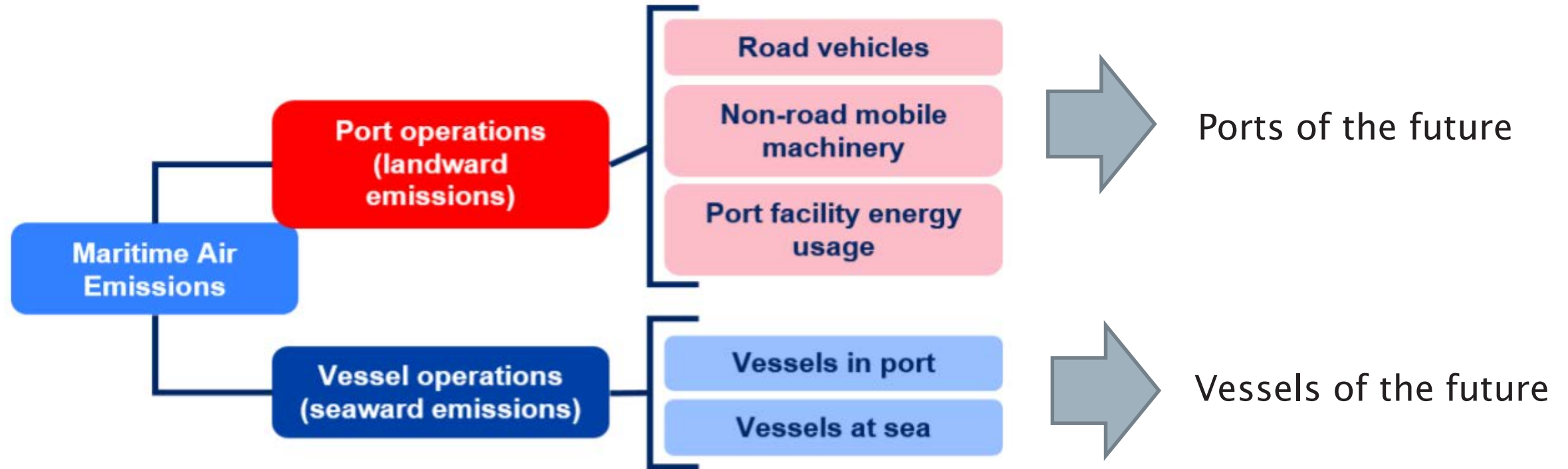
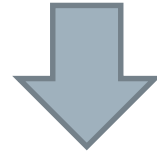


Figure 14 - Sources of maritime air pollution

VESSELS OF THE FUTURE

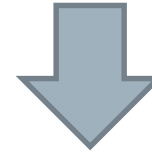
Vision, challenges and potential solutions

Low emission fuels and Fuel efficiency



Future Fuels

Biofuels
Hydrogen
Ammonia
Methanol
LNG
Electrification



Vessel Efficiency

Hull shape/form
Propulsion

System Efficiency

Automation
Digitisation
Optimization

PORTS OF THE FUTURE

Vision, challenges and potential solutions

Future fuel capability – Low emission port ops – Low emission connections



Infrastructure

Fueling
Storage



System Efficiency

Automation
Digitisation
Optimization
Electrification
Tugboats
Work vessels
Port machinery



Transport links

Rail vs Road
Electric Vehicle support
Access away from urban centres
HGV waiting places

EMISSIONS REDUCTION

Selected solutions – Maritime 2050

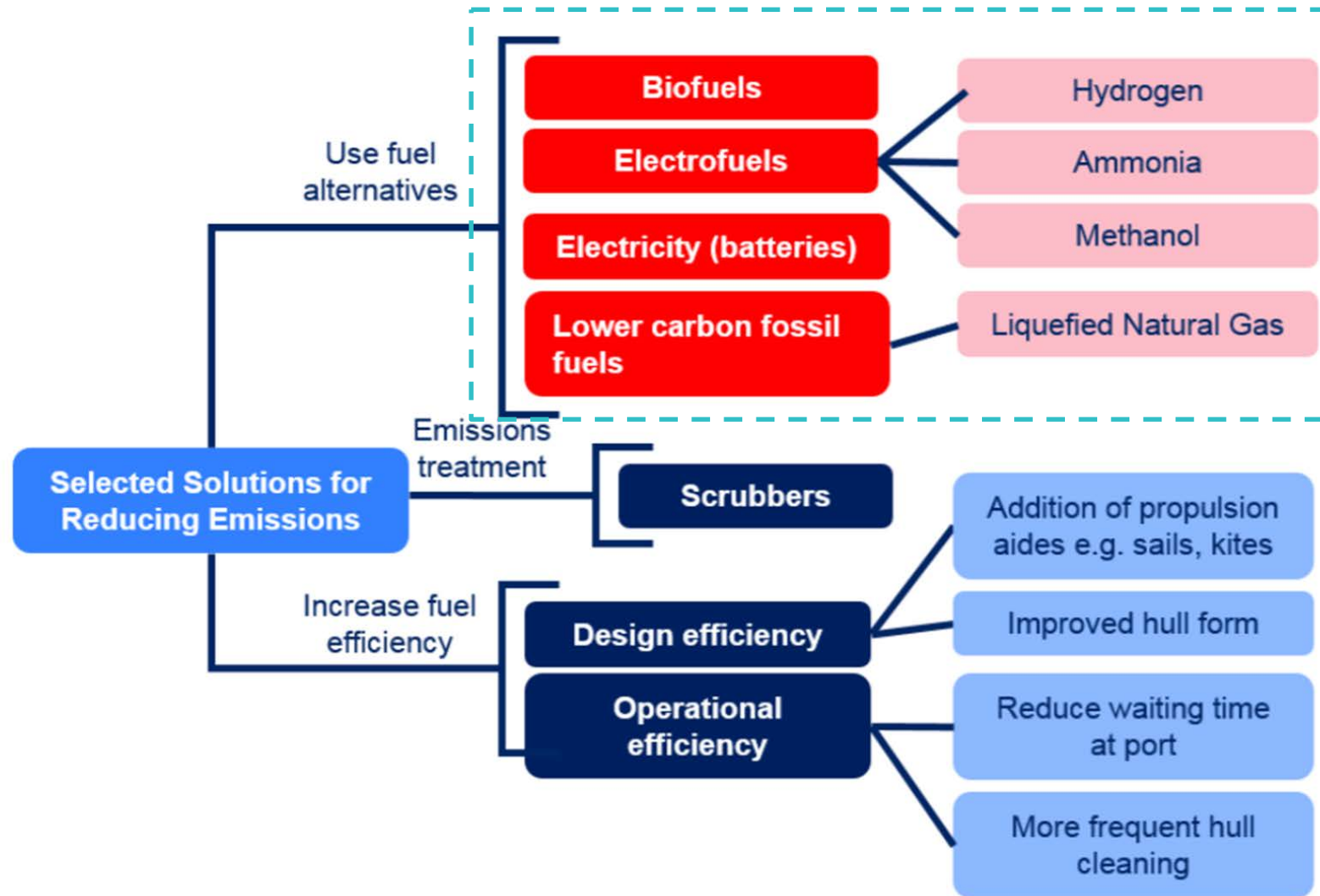


Figure 15 - Selected solutions to reducing emissions

FUTURE FUELS

Challenges to uptake

- Biofuels
 - Capacity – requires significant land use and bioresources for production
 - Expensive – likely to be more accessible to airlines and road vehicles before maritime transport
 - Look elsewhere ...
- Electrofuels - Hydrogen/Ammonia/Methanol
 - Highly toxic, combustible, cryogenic
 - Uncertainty of material integrity of storage and transmission equipment on board
 - Research to better understand FF and develop necessary infrastructure
- LNG
 - Transition fuel towards zero emission fuels, cleanest of fossil fuels
 - Change in infrastructure in vessel and portside infrastructure
 - Existing knowledge and exemplars – further research for scale and optimization¹¹

FUTURE FUELS

Renewable energy supply

- Massive renewable energy generation capacity required to make future fuels ‘clean’
- Net emissions not reduced by making future fuels with low emissions at point of consumption from burning fossil fuels.
- Research to address technology gaps across the lifecycle of renewable energy facilities to make economically competitive.



Characterisation - Create intelligent site characterisation tools for autonomous deployment or operation to upscale capability without upscaling cost



Sensing - Create living designs by embedding intelligent sensing in engineered ocean systems that inform on system health and ultimately self-certify



Stationkeeping - Create smart mooring and anchor systems for efficient and stable platforms in increasingly harsh environments

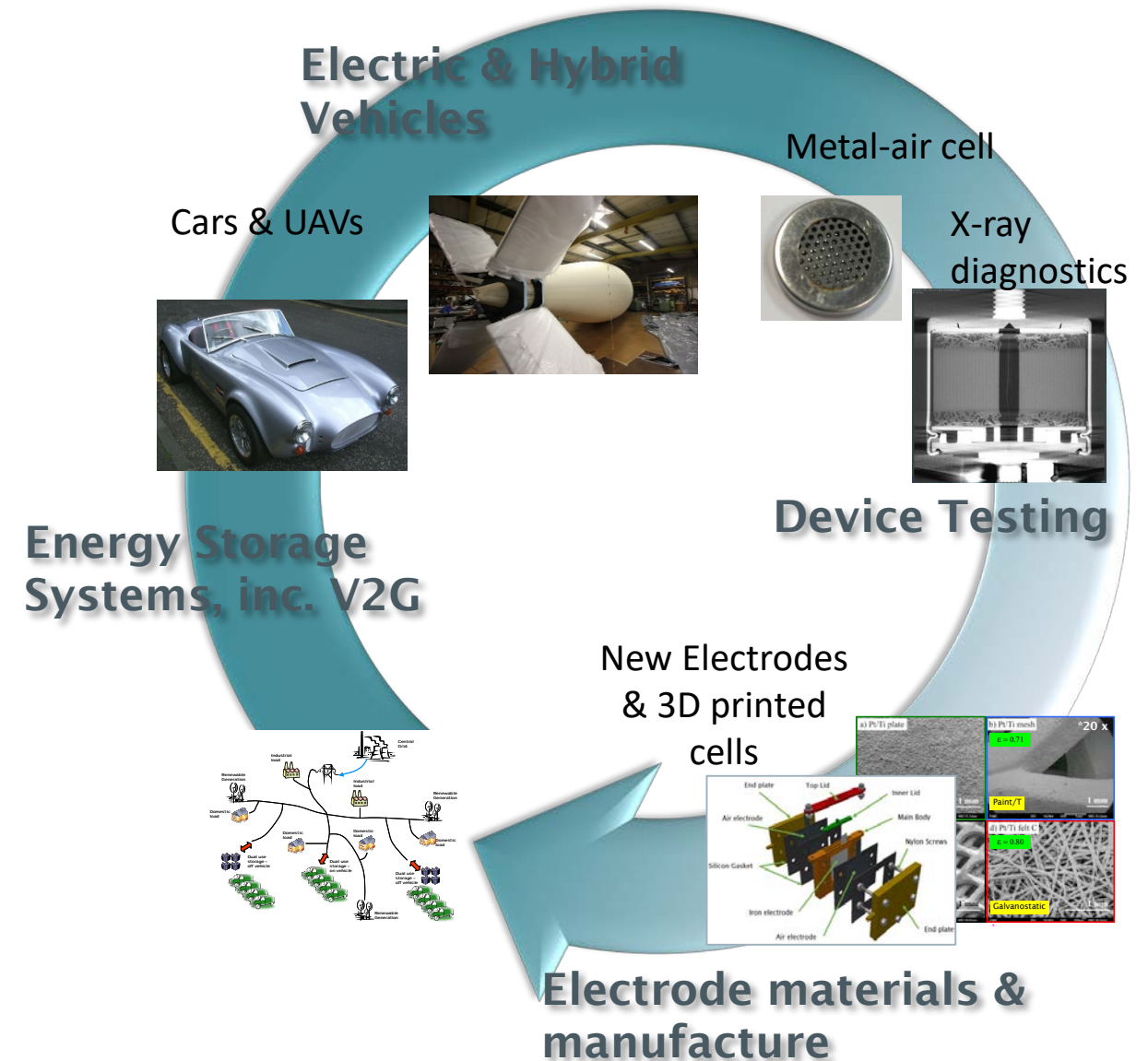


Design - Create next gen concepts and methodologies, enabling modular mass produced intelligent systems, performance-based design and optimal life-cycle cost

ELECTRIFICATION

Storage

- Research Challenges
 - Amount of storage & rate of transfer
 - Tailor battery for application
 - Cost, power, capacity, service life, degradation, environmental impact...
 - 3D printed cells
 - Sustainability
 - Non-lithium chemistries
 - Readily recyclable
 - Integration of Energy Storage



EMISSIONS REDUCTION

Selected solutions – Maritime 2050

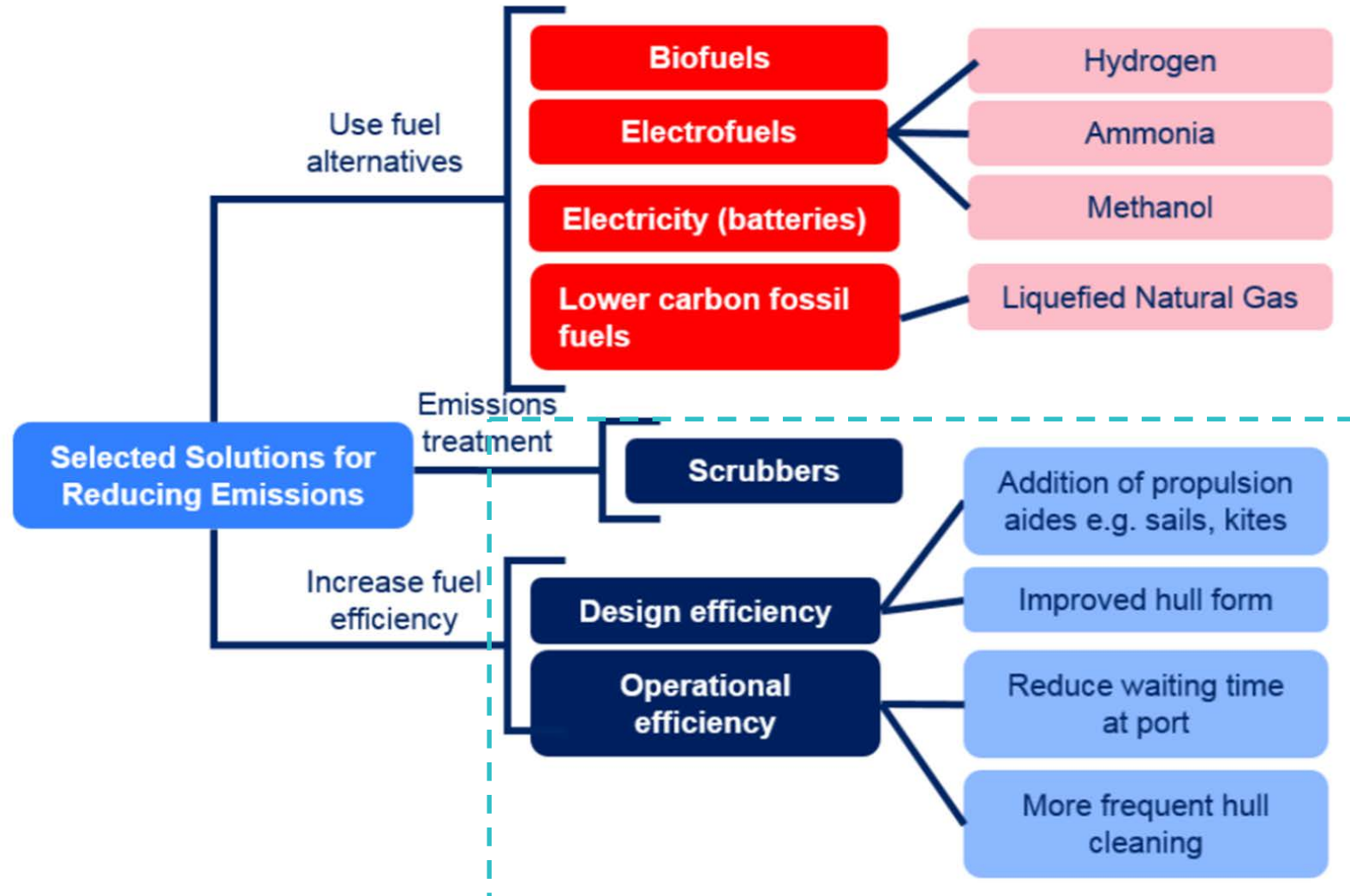
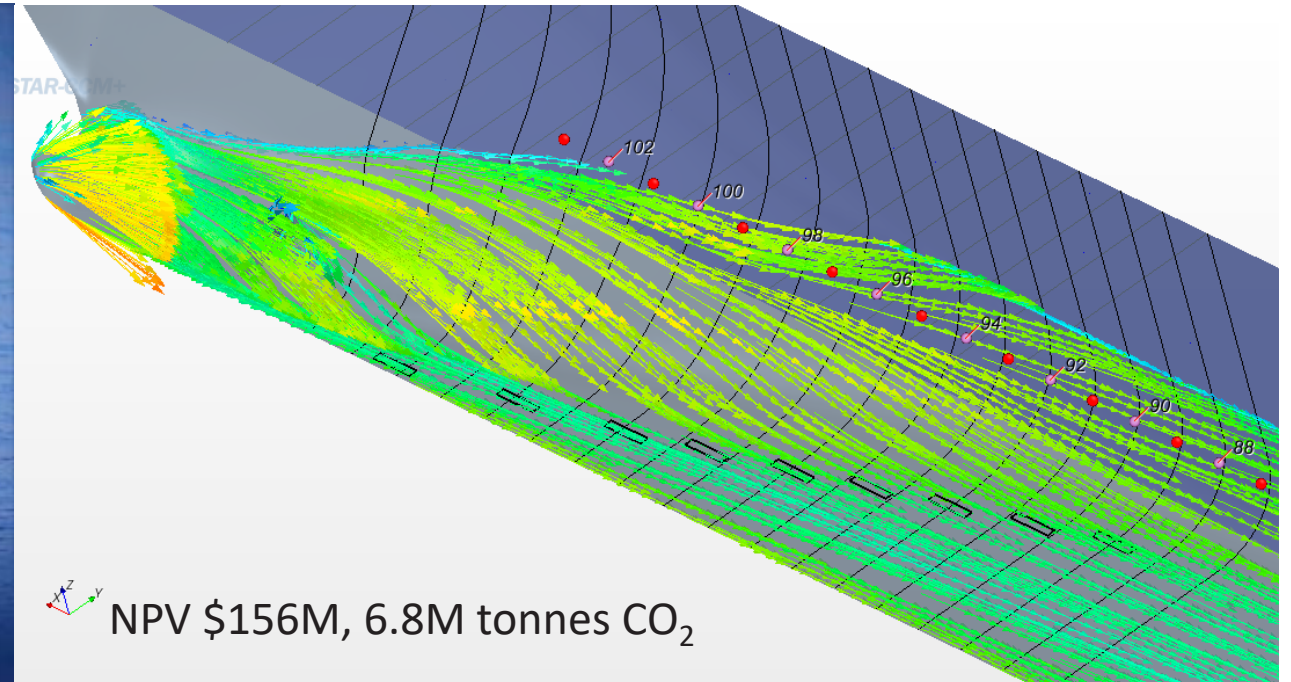


Figure 15 - Selected solutions to reducing emissions

VESSEL EFFICIENCY

Reducing drag

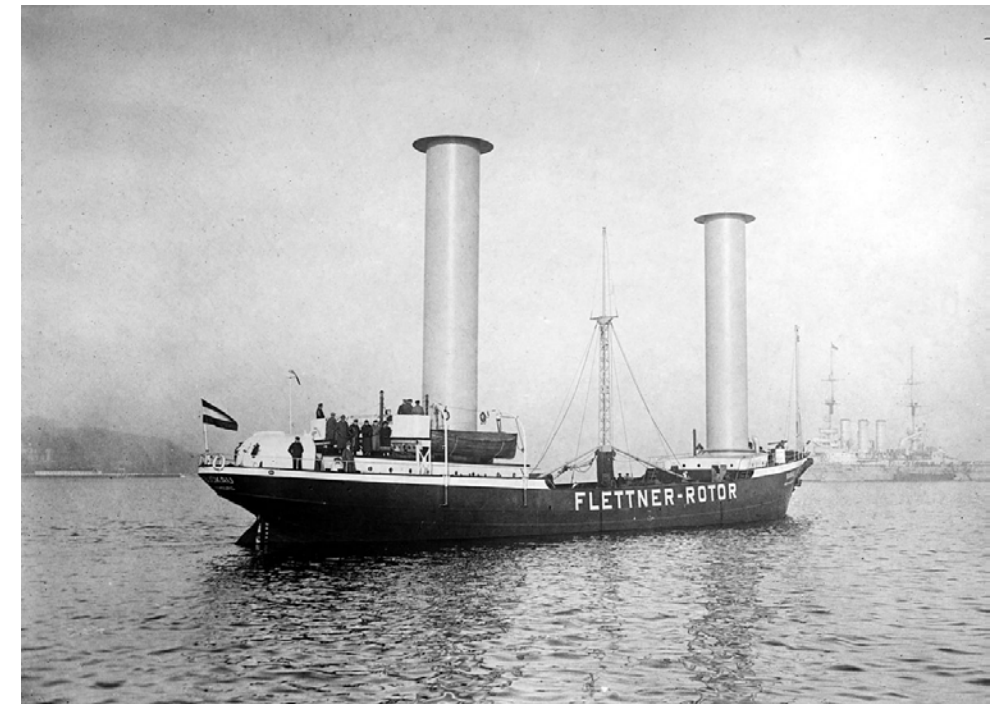
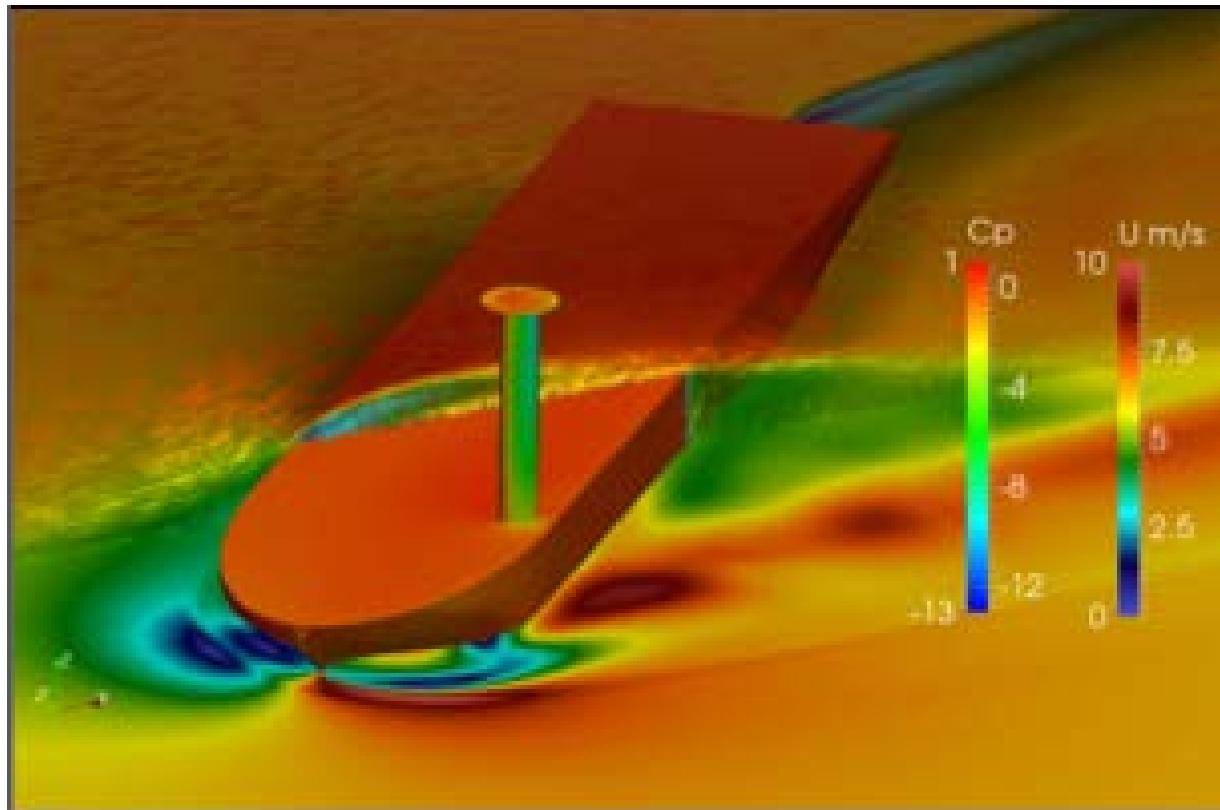
- Air lubrication systems. Layer of micro-bubbles lubricates underside of hull - reducing drag and reducing emissions by 5 – 10%.
- UoS projects to model systems and determine feasibility of using Machine Learning to optimise the operation



VESSEL EFFICIENCY

Wind-assist technology

- CFD of Flettner rotors for oil and LNG carriers
- NPV \$6.2M, 0.5M tonnes CO₂



VESSEL EFFICIENCY

Improved propulsion

- Bio inspired propulsion – resonant robot
- Most efficient accelerator underwater – officially!



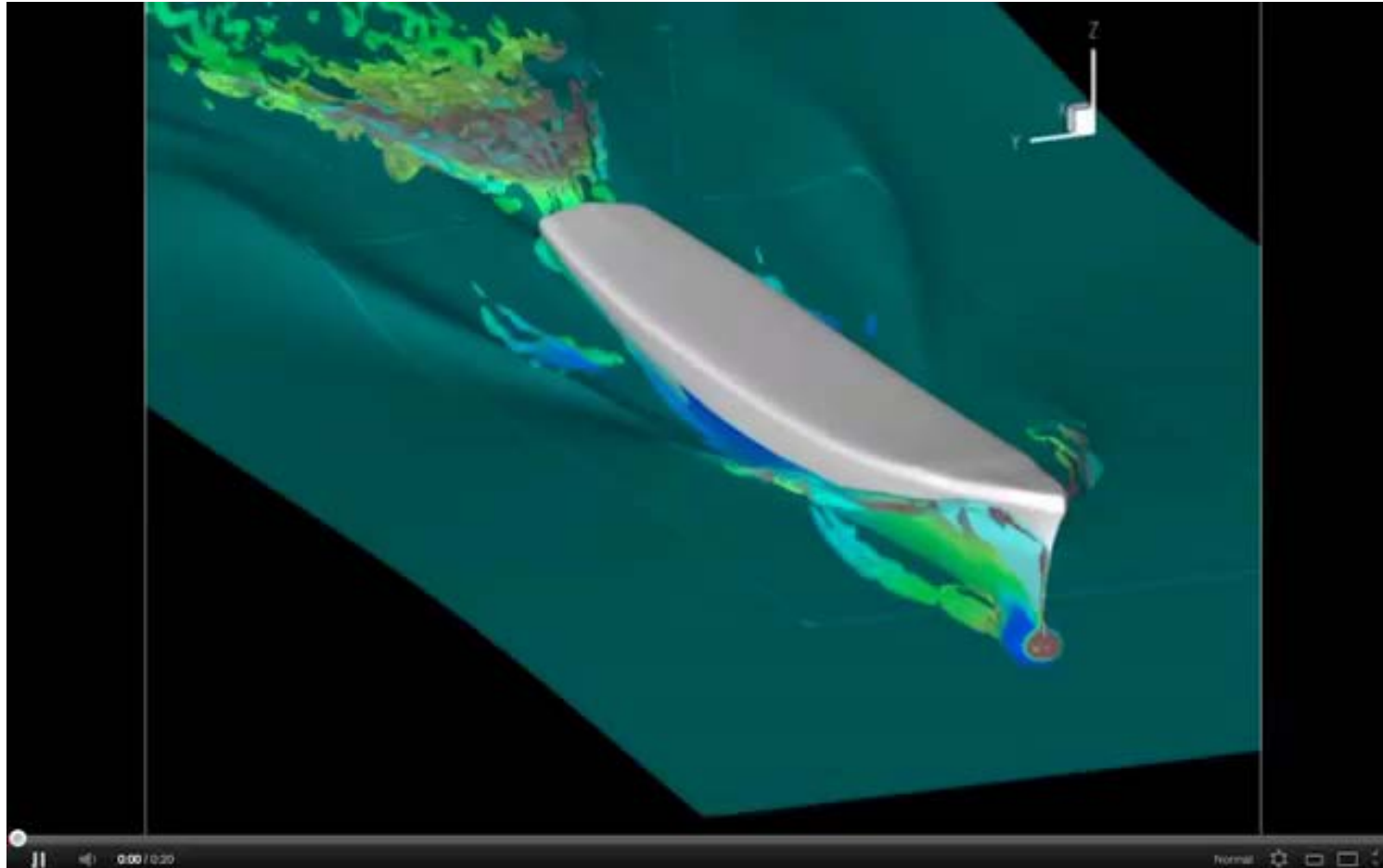
Gabe Weymouth, University of Southampton



SYSTEM EFFICIENCY

Physics-based ML for real time management

- Sparse Data Surrogate Models using Physics-Based ML



VESSELS & PORTS OF THE FUTURE

Barriers and solutions to realizing the vision to meet the environmental challenge

Technology



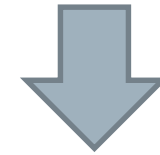
Infrastructure



People



Regulation



**Future Fuels
Electrification
Generation/Storage
Vessel efficiency
System efficiency
Automation/Digitisation**

**Transforming
infrastructure while
operating at full
capacity**

**Change in
workforce skill
requirements.
Training &
re-training**

**Progressive forward
looking regulation to
enable uptake of new
technologies to meet
clean growth
demand**

THINKING BIGGER

How else can the maritime sector contribute to clean growth?

- Challenge that Maritime has greater role to play in clean growth than just reduction of emissions from shipping.
- Oceans have SPACE for:
 - Renewable energy generation
 - Carbon Capture and Storage
 - Low carbon food production (fish, seaweed)
- Inlets and coastlines are crowded – oceans provide space to generate energy, create food, store CO₂

Maritime 2050 values and ambitions

Maritime 2050 Strategic Ambitions

The UK will...

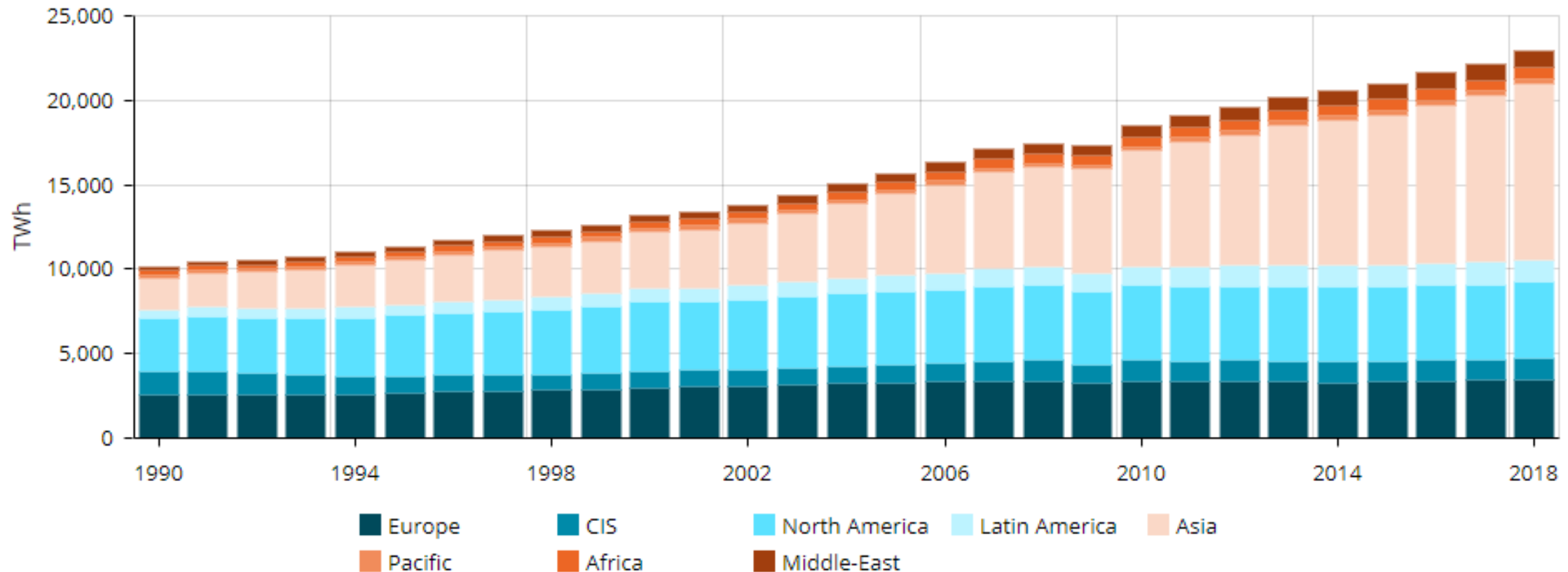
- Maximise our strength in maritime professional services, retaining and enhancing our **UK competitive advantage** in the provision of maritime law, finance, insurance, management and brokering, and developing our green finance offer.
- Lead the way in taking action on **clean maritime growth** enjoying economic benefits from being an early adopter or fast mover.
- Strengthen our reputation for maritime innovation, maximising benefits to the UK from new **maritime technology** through our world leading universities, maritime small and medium enterprises (SMEs) and global companies.

THINKING BIGGER

How else can the maritime sector contribute to clean growth?

Renewable energy

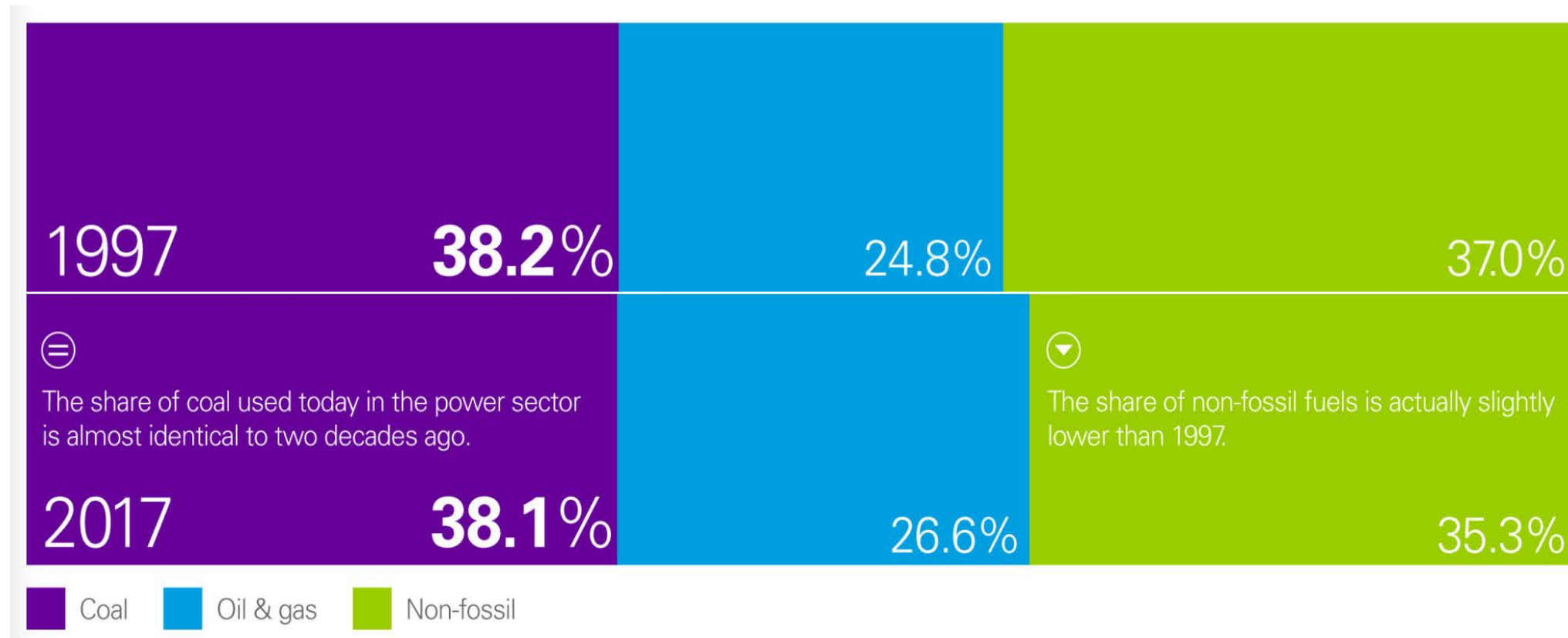
- Global electricity consumption forecast to continue increase ...



THINKING BIGGER

How else can the maritime sector contribute to clean growth?

- Fuel shares in power generation - share of non-fossil fuels for Electricity Generation in 2017 was LOWER than in 1997 (power generation much greater!)



Business opportunity for maritime industry in development of offshore renewable energy

<https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html>

THINKING BIGGER

How else can the maritime sector contribute to clean growth?

Carbon capture and storage

- In terms of volume CCS is potentially a larger industry than the oil business.

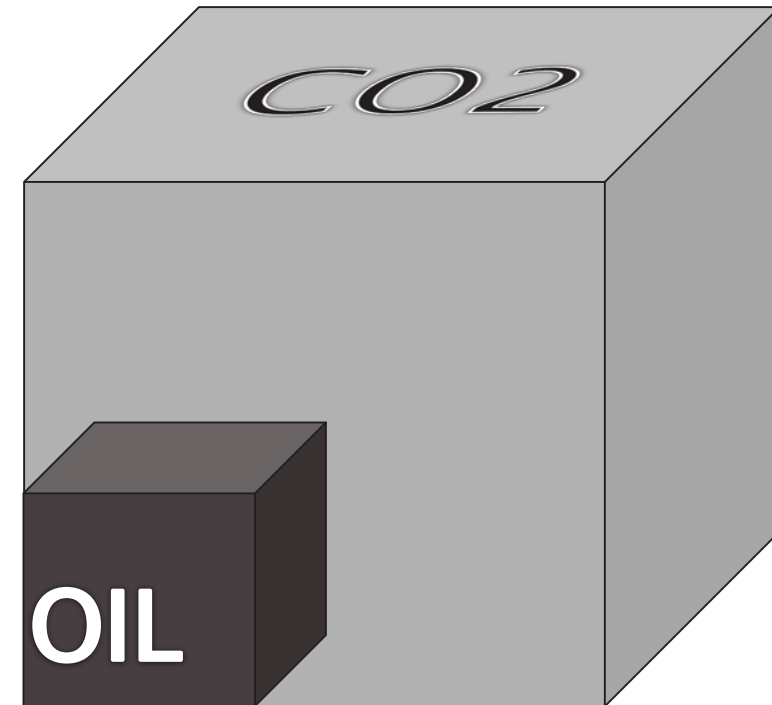
Capture all 37 Gt/yr CO₂ emissions annually

Compress to critical point (73.82 b)

79.2 bn m³ = cube of side 4.3 km.

World oil production is 3.88 Gt/y

4.52 bn m³ = cube of side 1.7 km.



After example by Richard Darton, Oxford

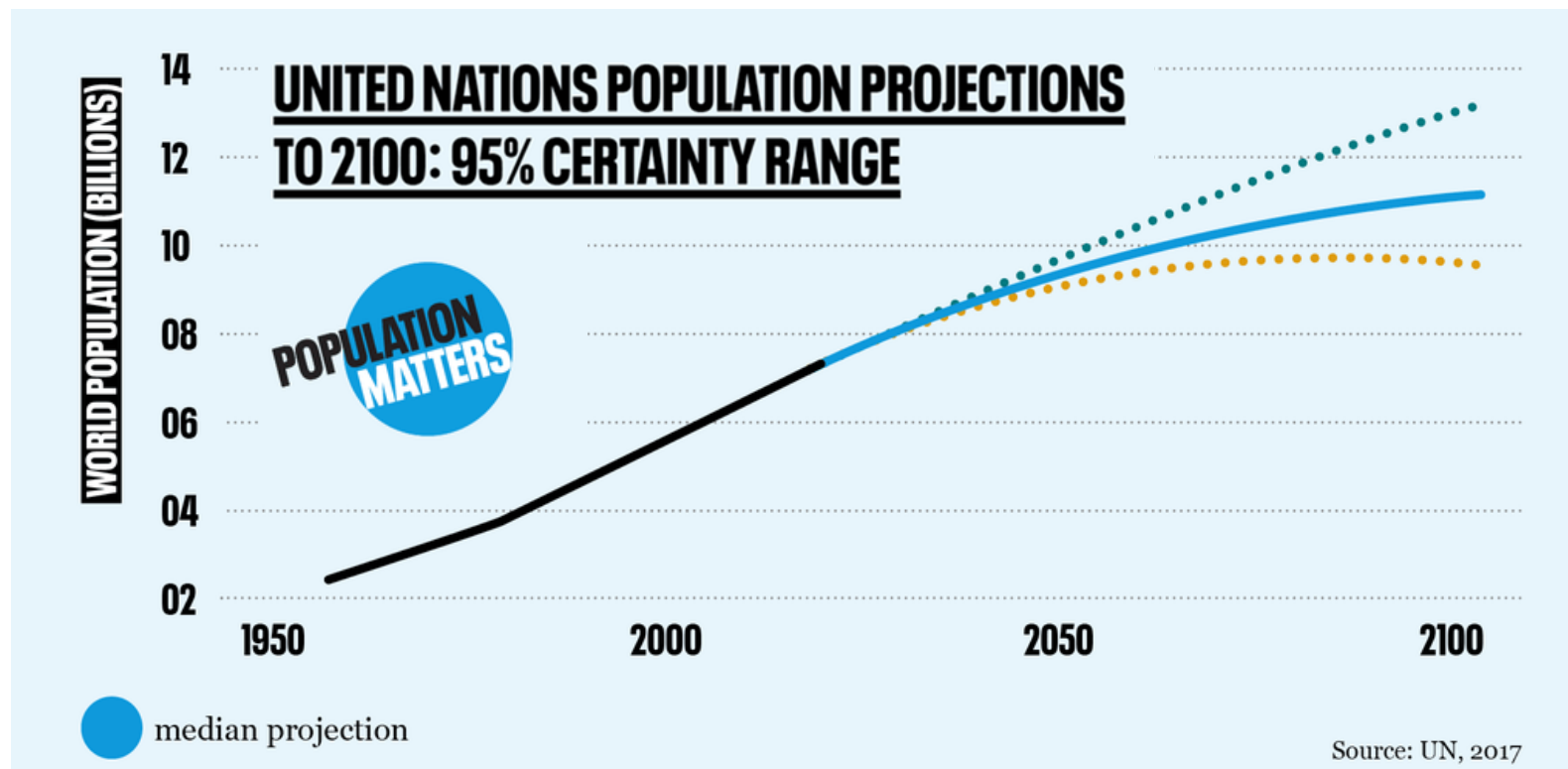
Business opportunity for maritime industry injecting supercritical CO₂ in deep rock reservoirs for storage

THINKING BIGGER

How else can the maritime sector contribute to clean growth?

Aquaculture

- To feed an additional 2 bn people by 2050 requires 60% increase in food production



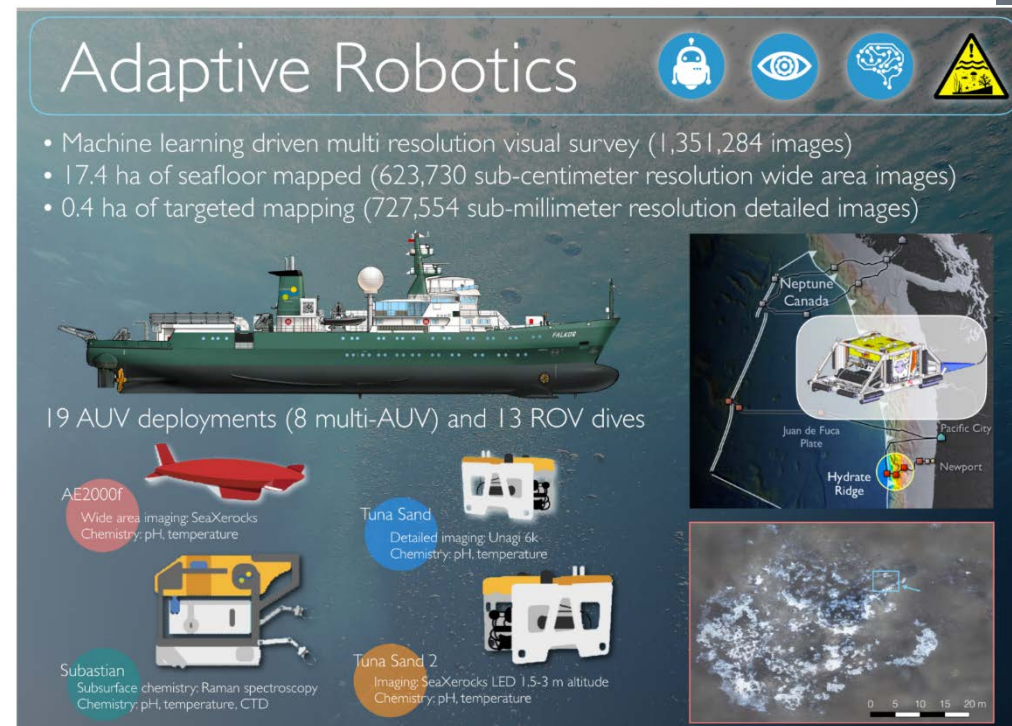
Business opportunity for maritime industry in development of aquaculture

http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf

THINKING BIGGER

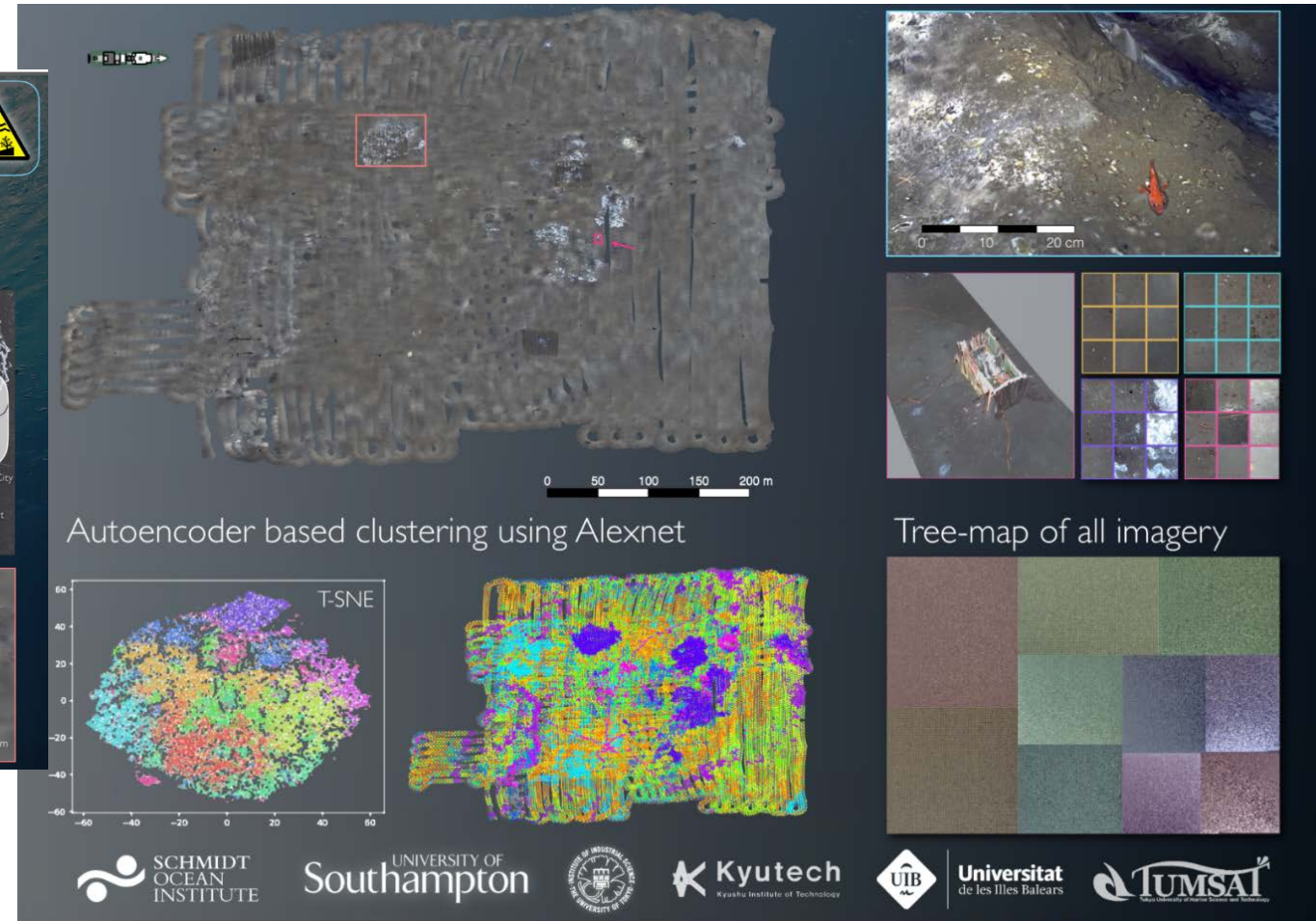
How else can the maritime sector contribute to clean growth?

Monitoring ocean health



Blair Thornton

<https://ocean.soton.ac.uk>



Business opportunity for maritime industry to create the evidence base to understand how our interventions are affecting the oceans in order to manage interventions responsibly. 25

'THE' ENVIRONMENTAL CHALLENGE

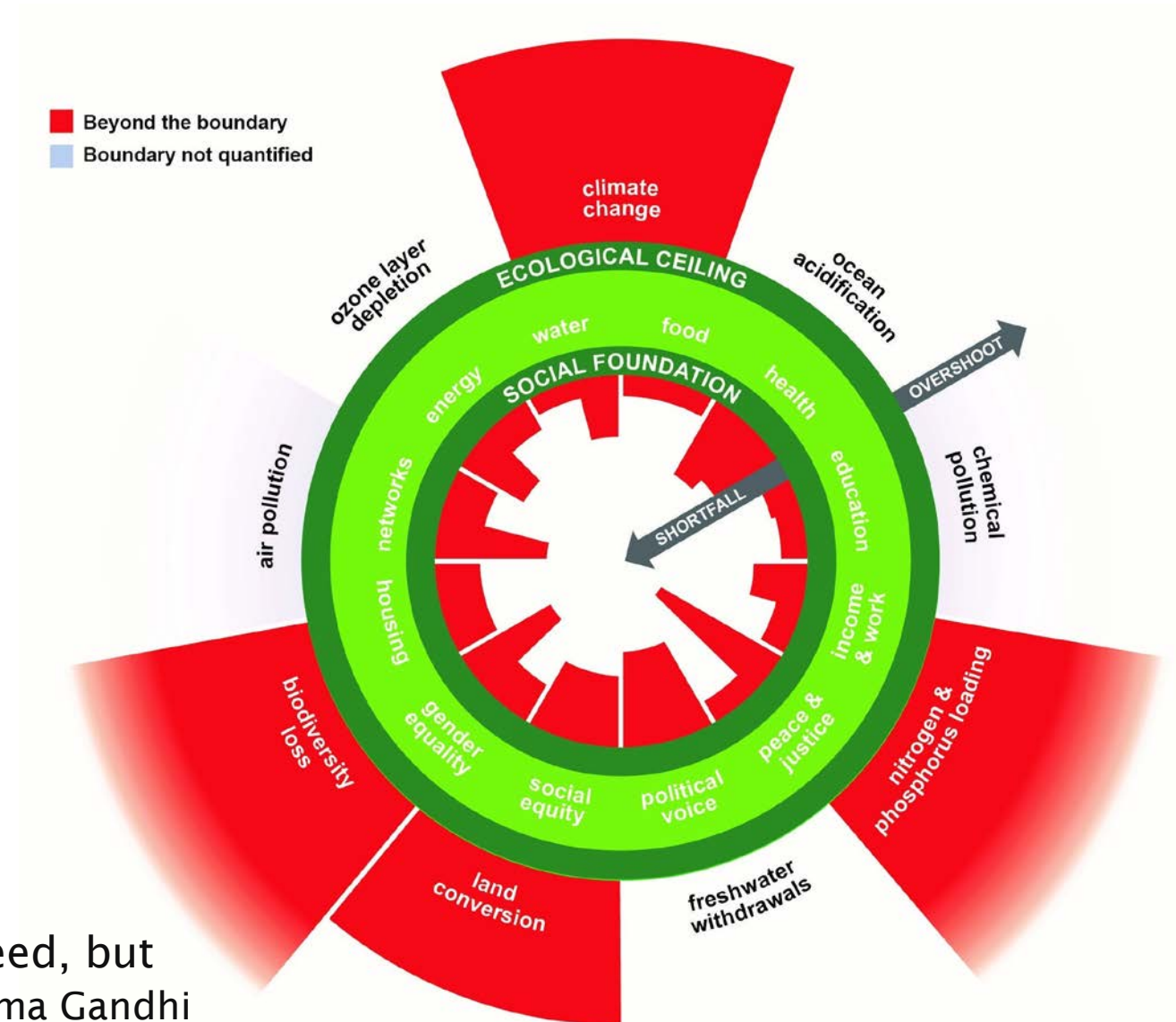
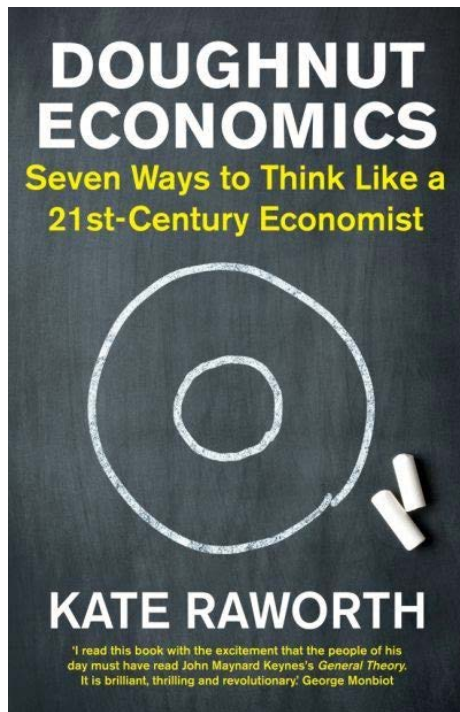
Demand and Limit

- Demand on the planet – Increased demand for resources, food, goods, energy for an increasing and increasingly wealthy global population pushing outwards
- Limit of the planet – Emissions limits and targets set by legislation or sense of environmental responsibility pushing inwards
- How to reconcile competing agendas?
- Rely on technology and innovation in absence of behaviour change.
- BUT ...

'THE' ECONOMIC MODEL TO MEET 'THE' ENVIRONMENTAL CHALLENGE

Doughnuts – Food for thought

- Must integrate consideration of demand and limit



“The world has enough for everyone's need, but not enough for everyone's greed.” Mahatma Gandhi

UNIVERSITY OF
Southampton



susan.gourvenec@southampton.ac.uk