Addressing the Challenges and Business Opportunities in Implementing Maritime 2050

Meeting the Environmental Challenge

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MARITIME 2050

The Environmental Challenge

7 themes:

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

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

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."

https://www.gov.uk/government/publications/clean-maritime-plan-maritime-2050-environment-route-map

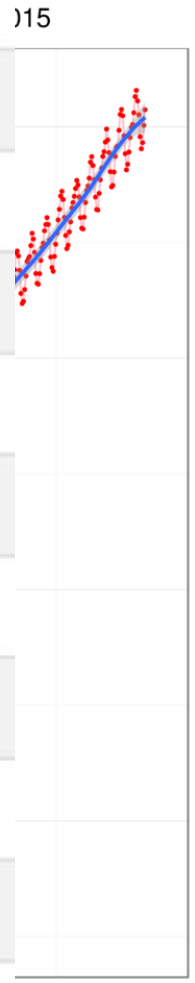
MARITIME AIR POLLUTION

Scale – taking CO_2 as example

- Global CO_2 emissions = 37 Gt/an
- 8 – 10Gt increase in CO2/an
- 15 Gt/an from stationary sources
- Global shipping emits 940 Mt CO_2/an = 2.5% of global emissions

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

Country	Total Emissions
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/

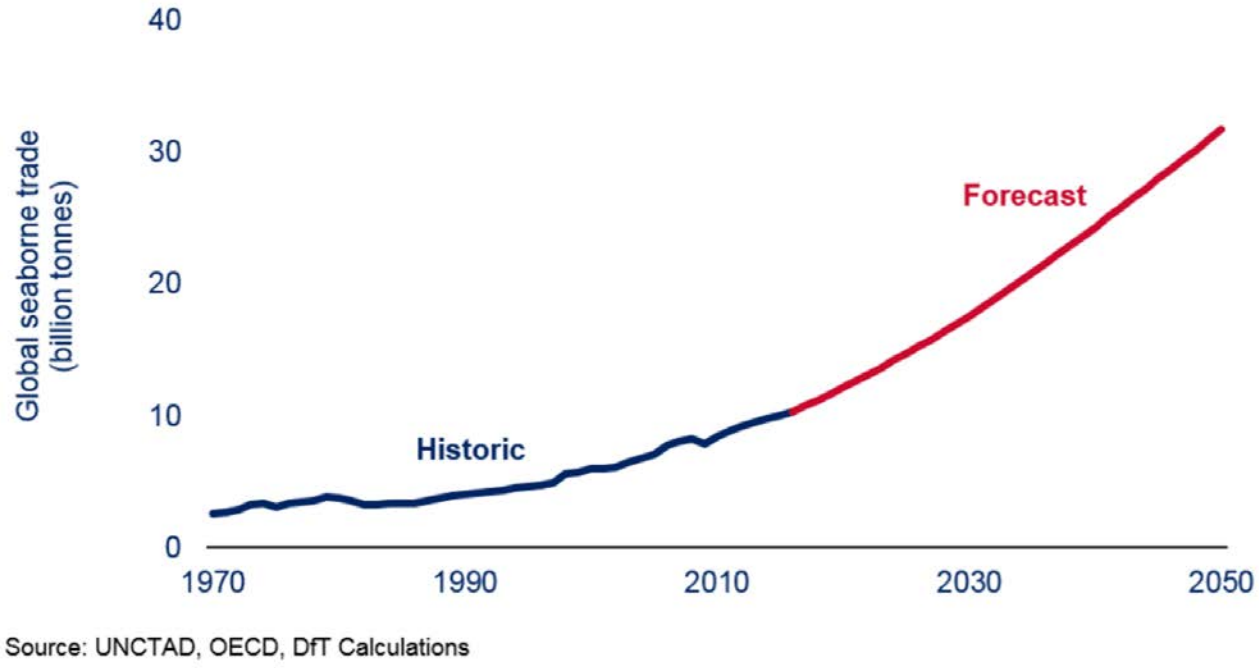
http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Greenhouse-Gas-Studies-2014.aspx

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

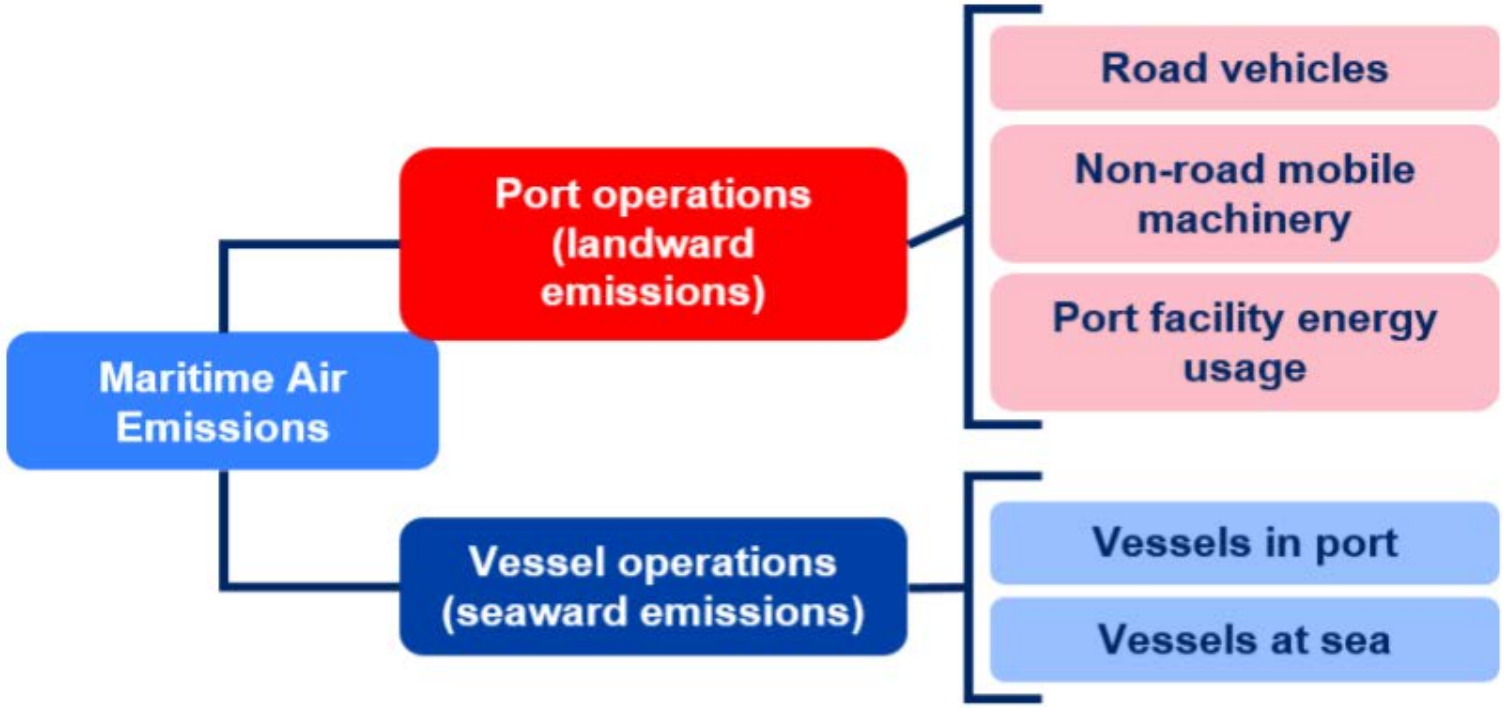


Figure 14 - Sources of maritime air pollution

Variety of pollution - CO_2, other GHGs, SOx, NOx, particulates …

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

MARITIME AIR POLLUTION

Sources

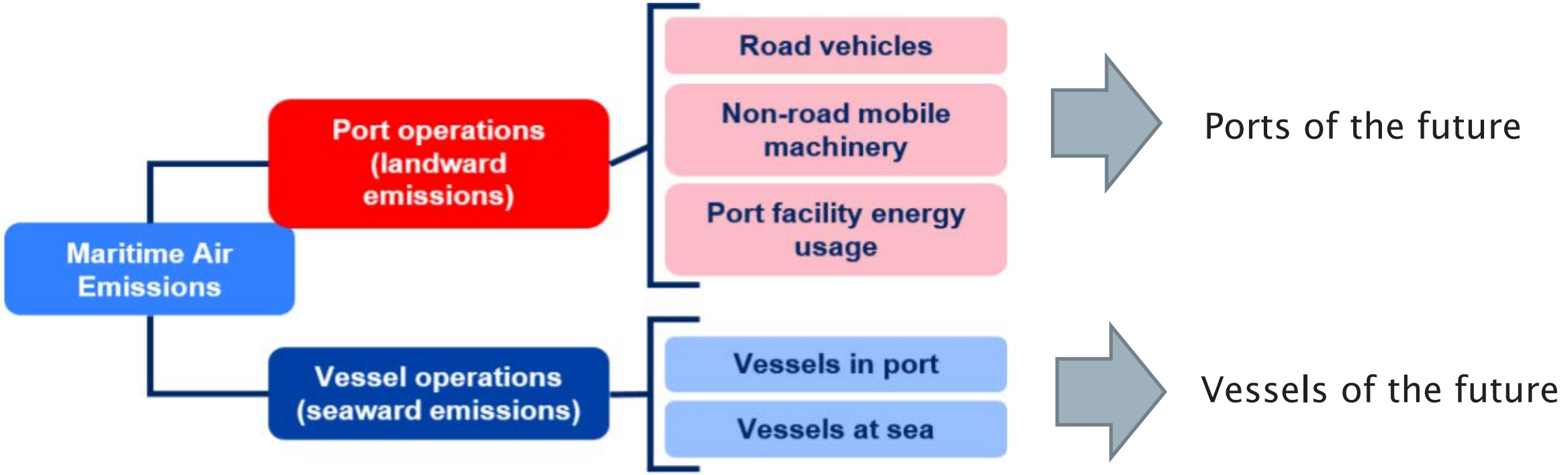


Figure 14 - Sources of maritime air pollution

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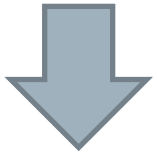
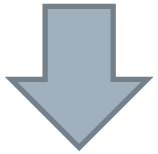
VESSELS OF THE FUTURE

Key Pathways

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

Key Pathways

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

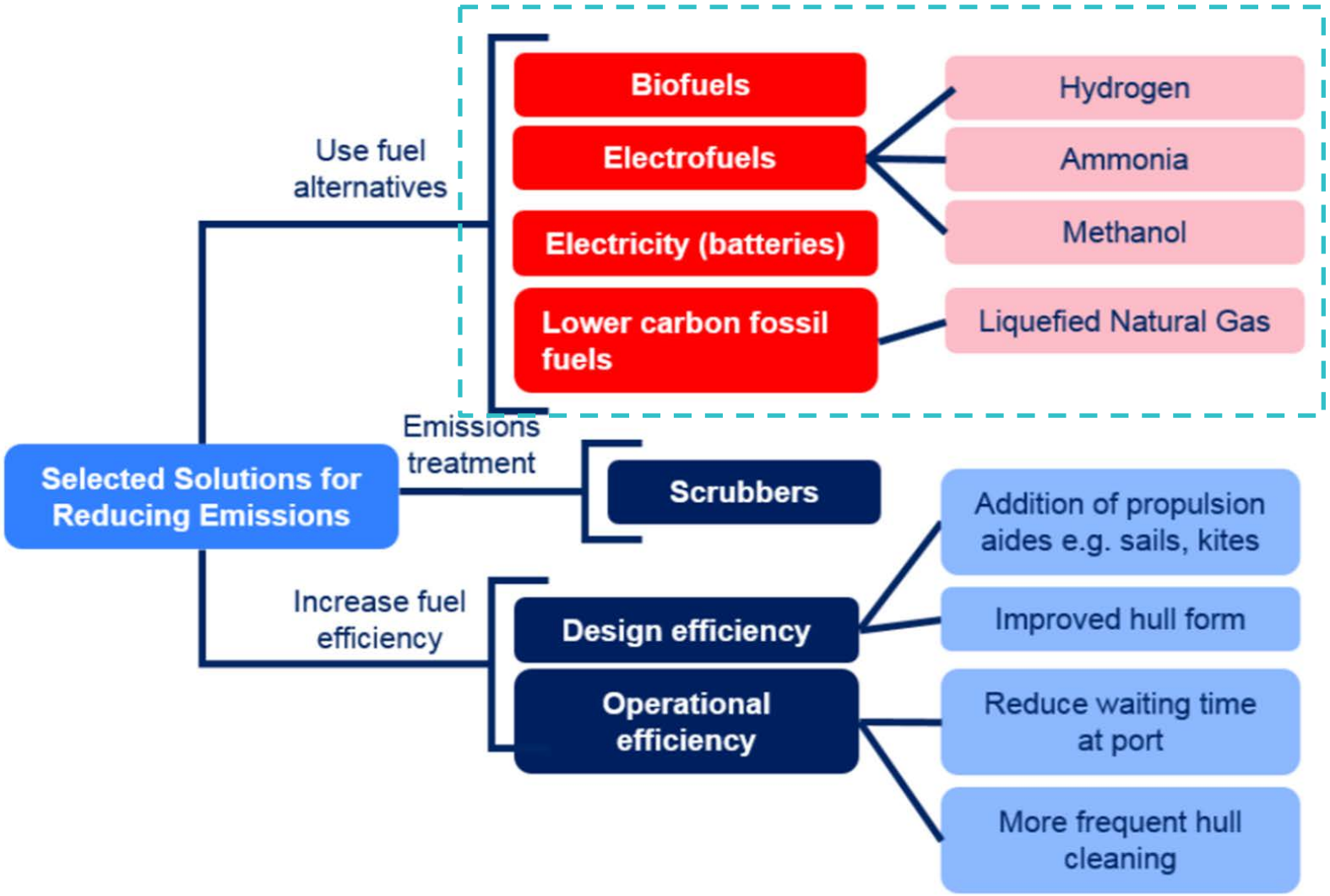


Figure 15 - Selected solutions to reducing emissions

FUTURE FUELS

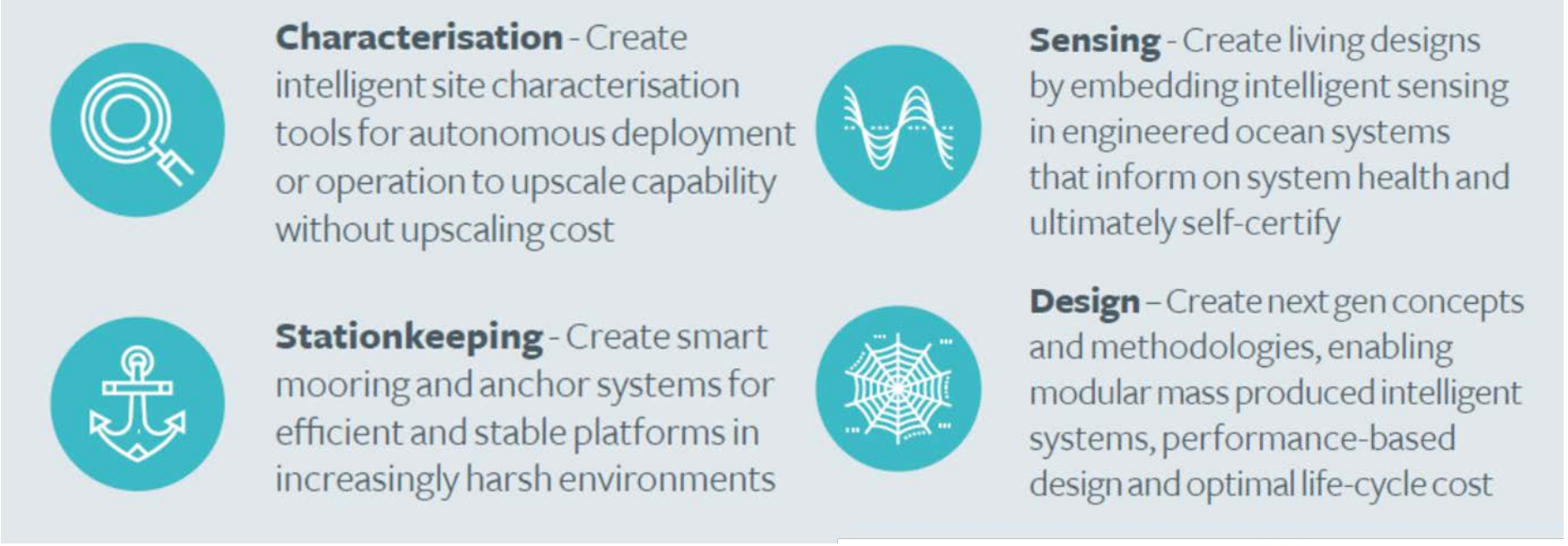
Challenges to uptake

- 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 optimization

FUTURE FUELS

Renewable energy supply

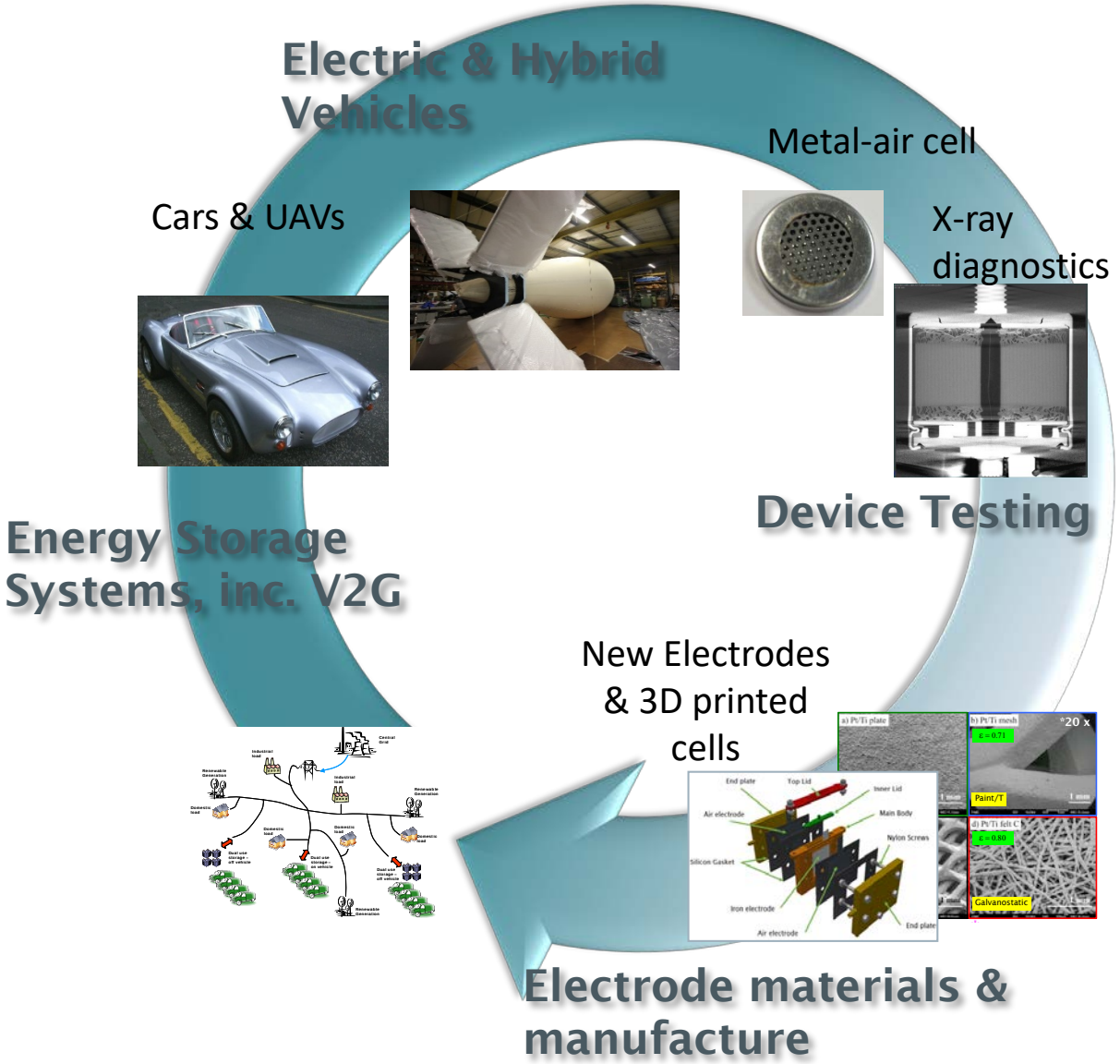
- Massive renewable energy generation capacity required to make future fuels ‘clean’
- Net emissions not reduced by making future fuels with low emissions at point of consumption from burning fossil fuels.
- Research to address technology gaps across the lifecycle of renewable energy facilities to make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



ELECTRIFICATOIN

Storage and transmission

- 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

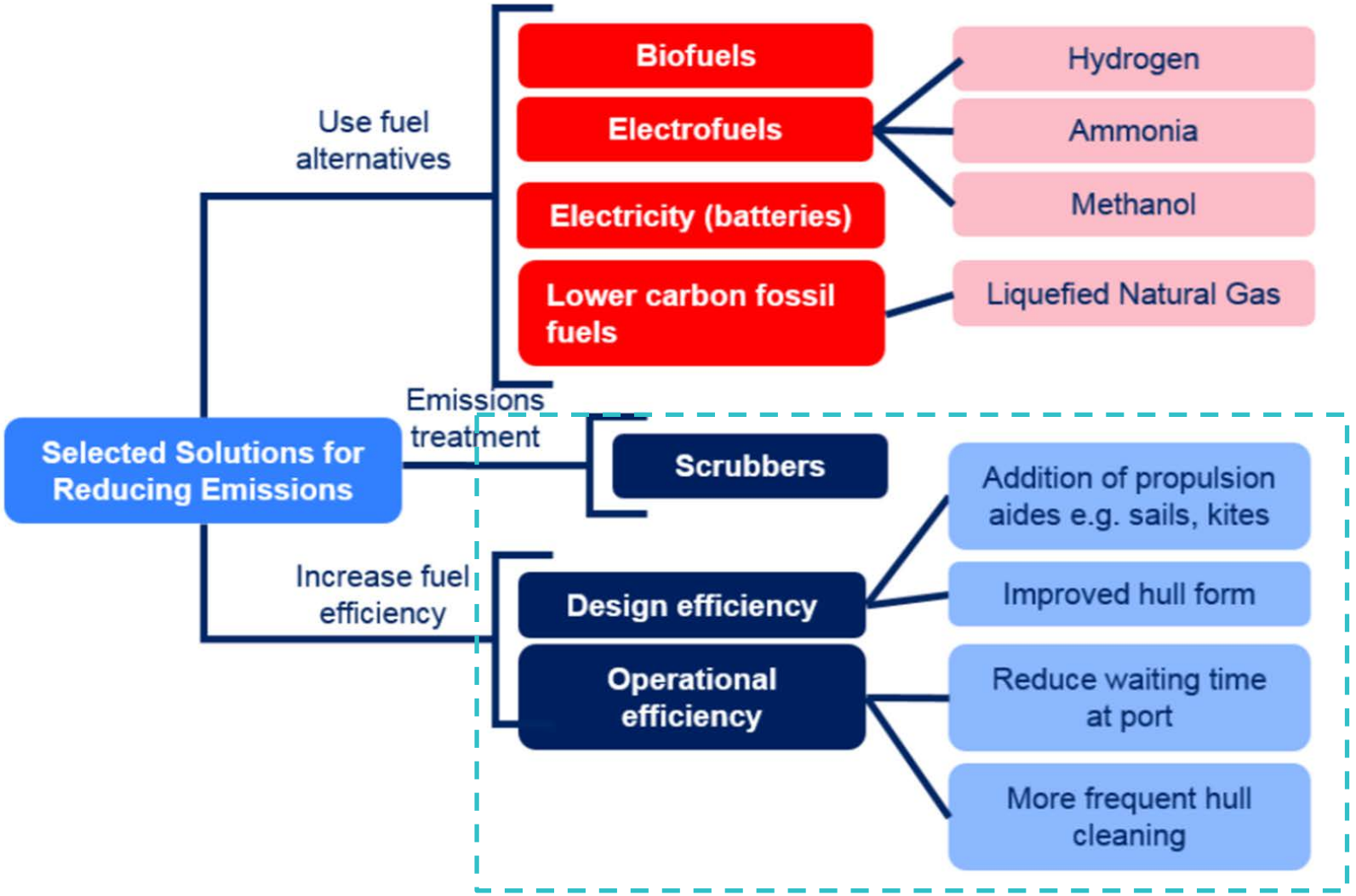


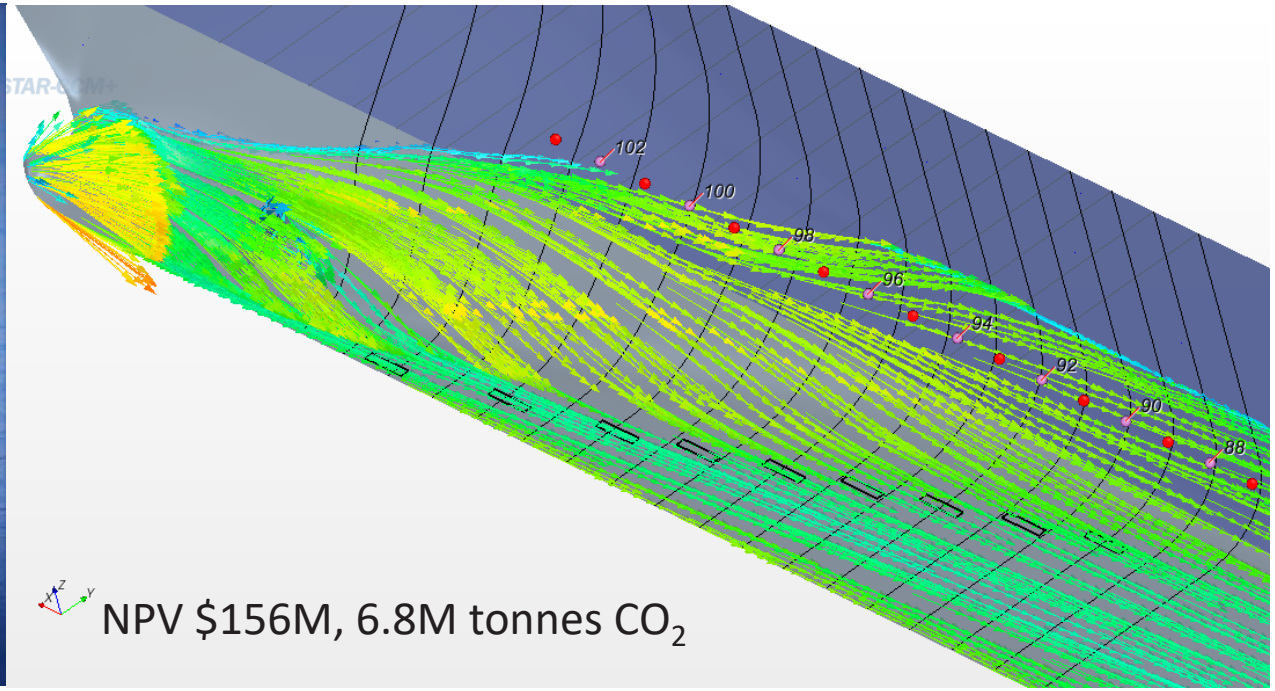
Figure 15 - Selected solutions to reducing emissions

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

https://www.silverstream-tech.com/silverstream_images-3/

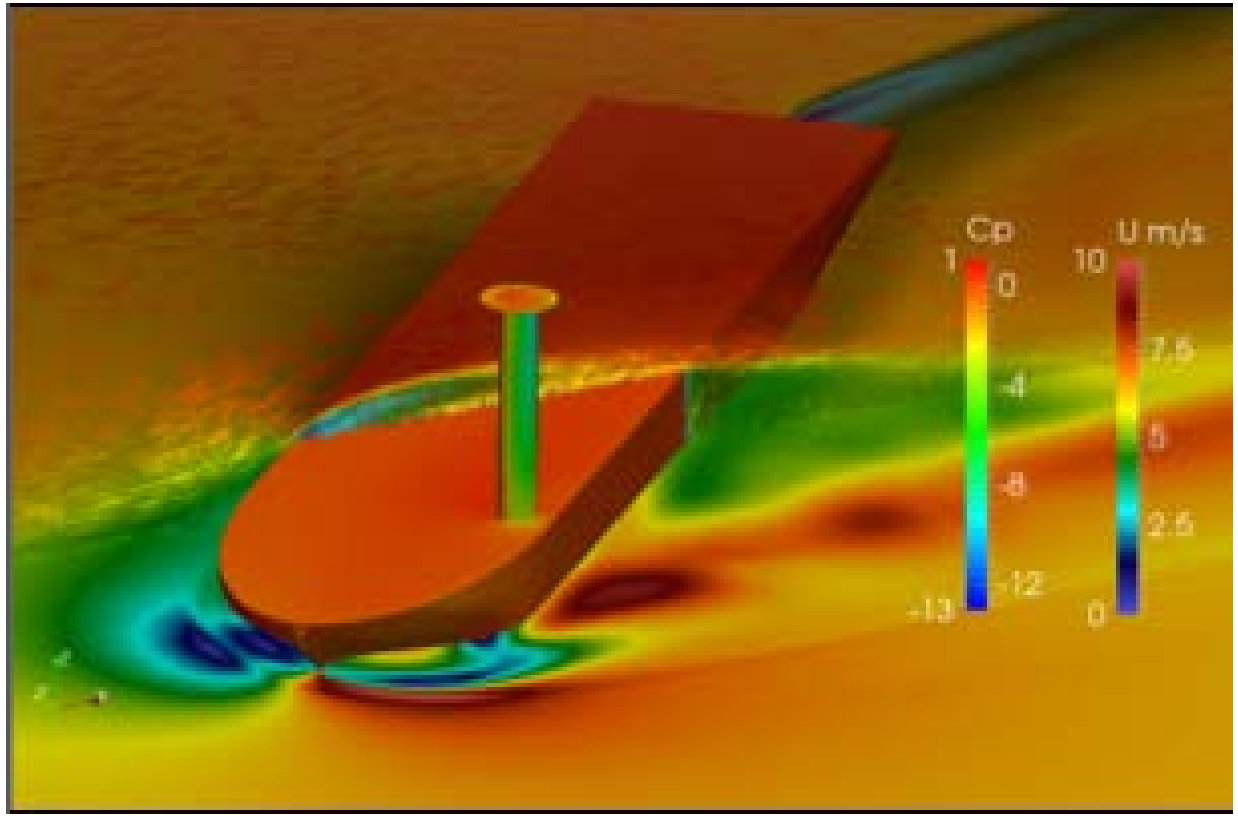


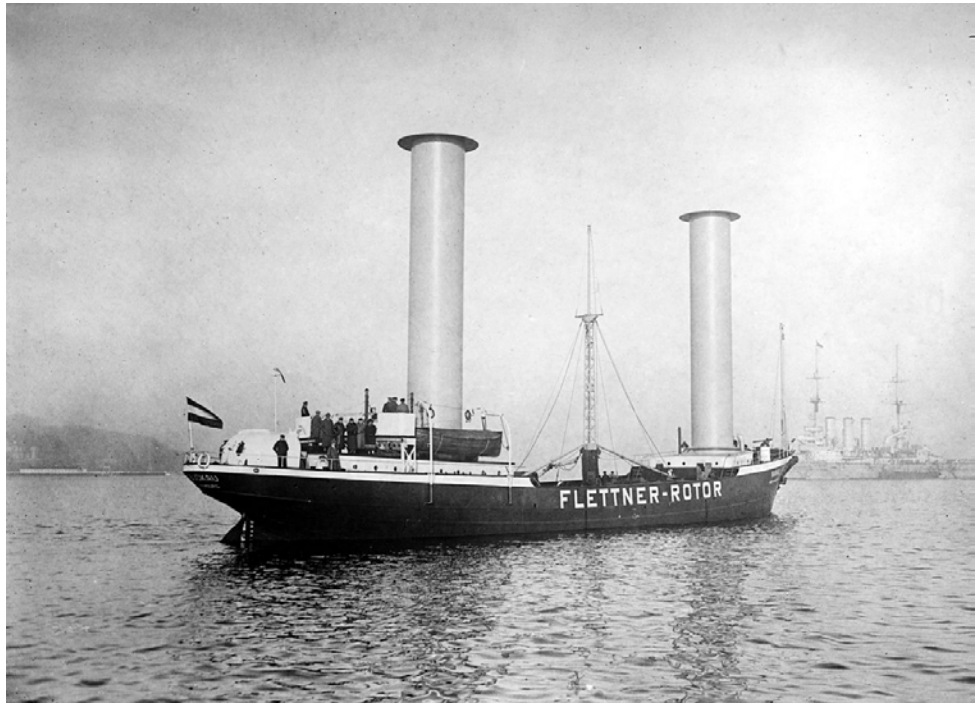
NPV $156M, 6.8M tonnes CO_2

VESSEL EFFICIENCY

Wind-assist technology

- CFD of Flettner rotors for oil and LNG carriers
- NPV $6.2M, 0.5M tonnes CO_2



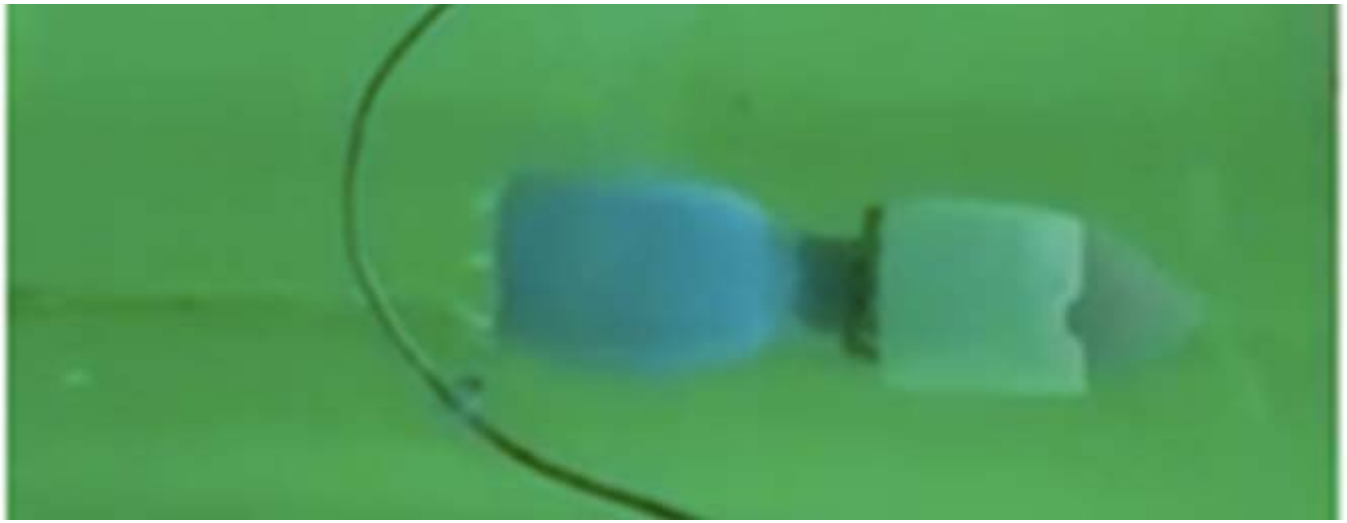


Dominic Hudson & Wolfson Unit, University of Southampton

VESSEL EFFICIENCY

Improved propulsion

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

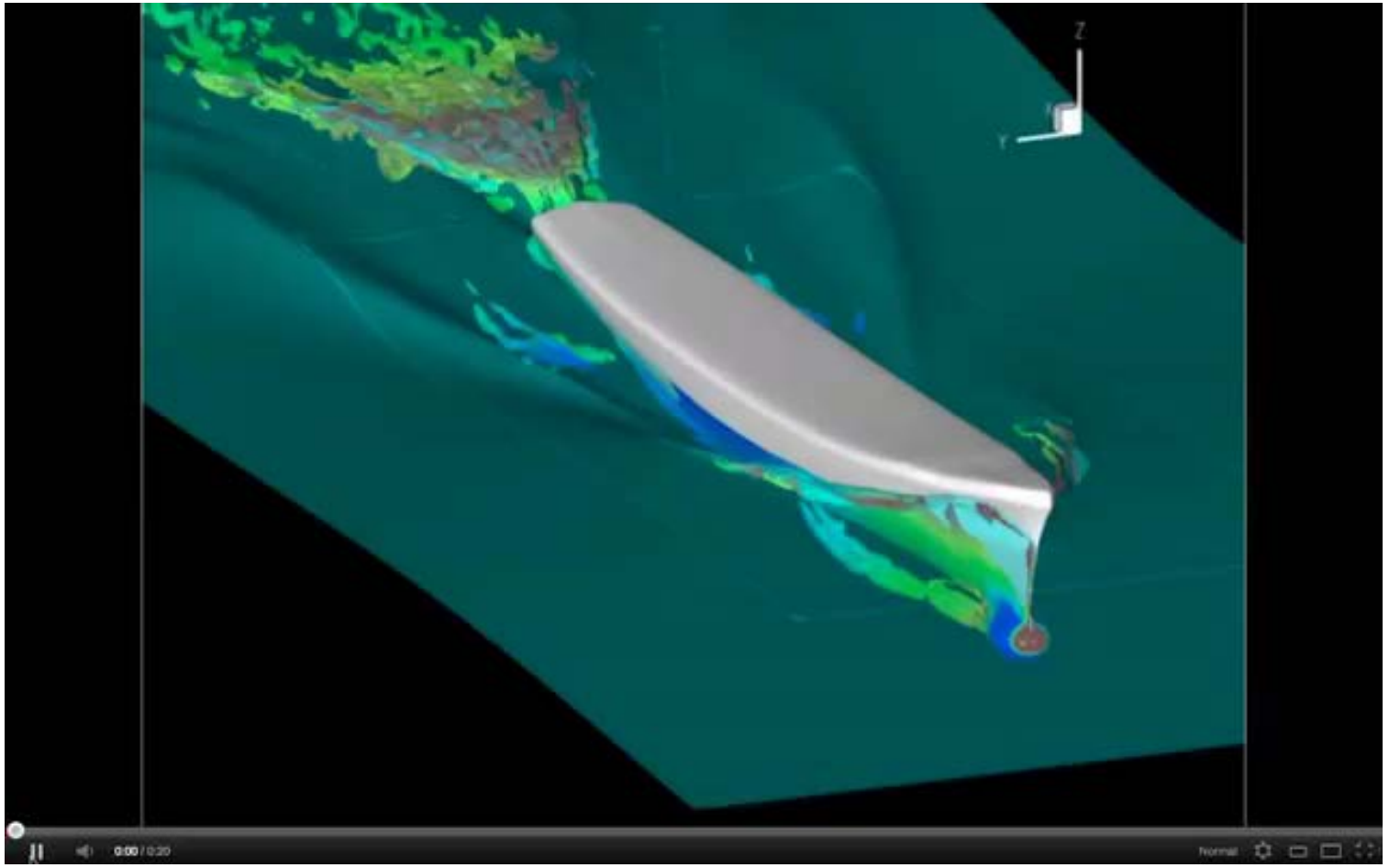


Gabe Weymouth, University of Southampton

SYSTEM EFFICIENCY

Physics-based ML for real time management

- Sparse Data Surrogate Models using Physics-Based ML



Gabe Weymouth, University of Southampton

VESSELS & PORTS OF THE FUTURE

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

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Technology

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

Infrastructure

Transforming infrastructure while operating at full capacity

People

Change in workforce skill requirements. Training & re-training

Regulation

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?

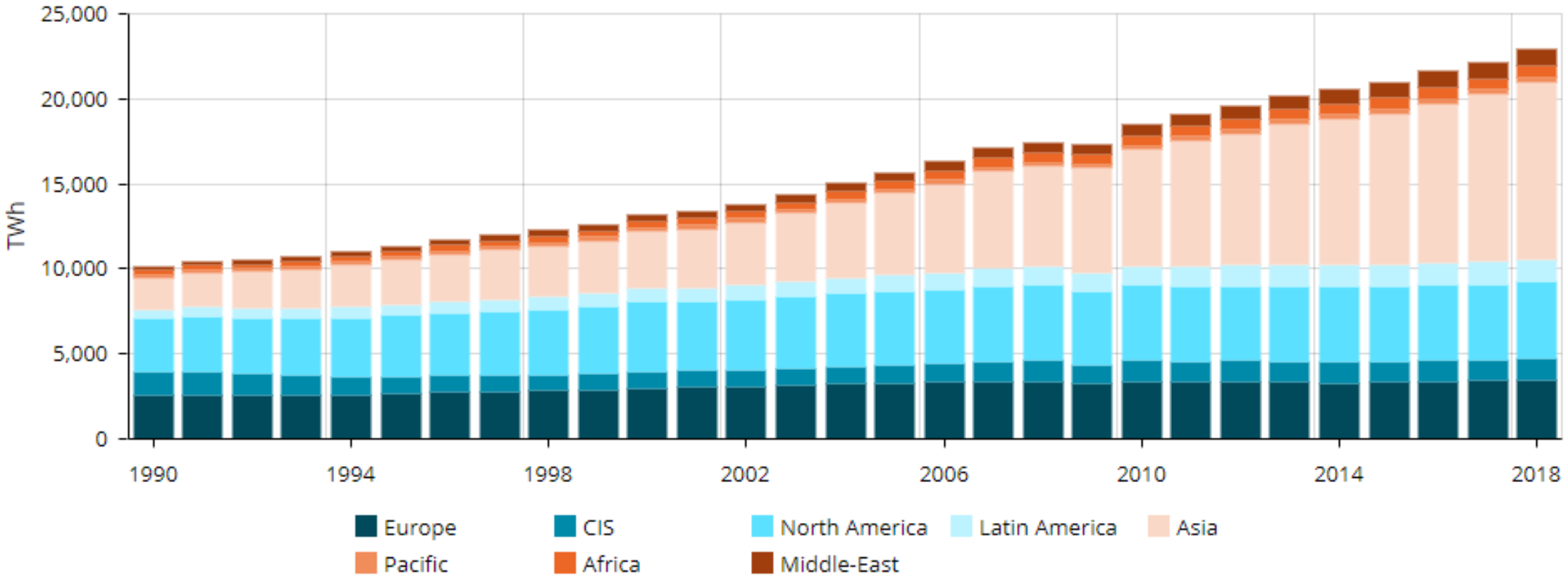
- Challenge that Maritime has greater role to play in clean growth than just reduction of emissions from shipping.
- Oceans have SPACE for:
  - Renewable energy generation
  - Carbon Capture and Storage
  - Low carbon food production (fish, seaweed)
- Inlets and coastlines are crowded – oceans provide space to generate energy, create food, store CO_2

THINKING BIGGER

How else can the maritime sector contribute to clean growth?

Renewable energy

- Global electricity consumption forecast to continue increase …

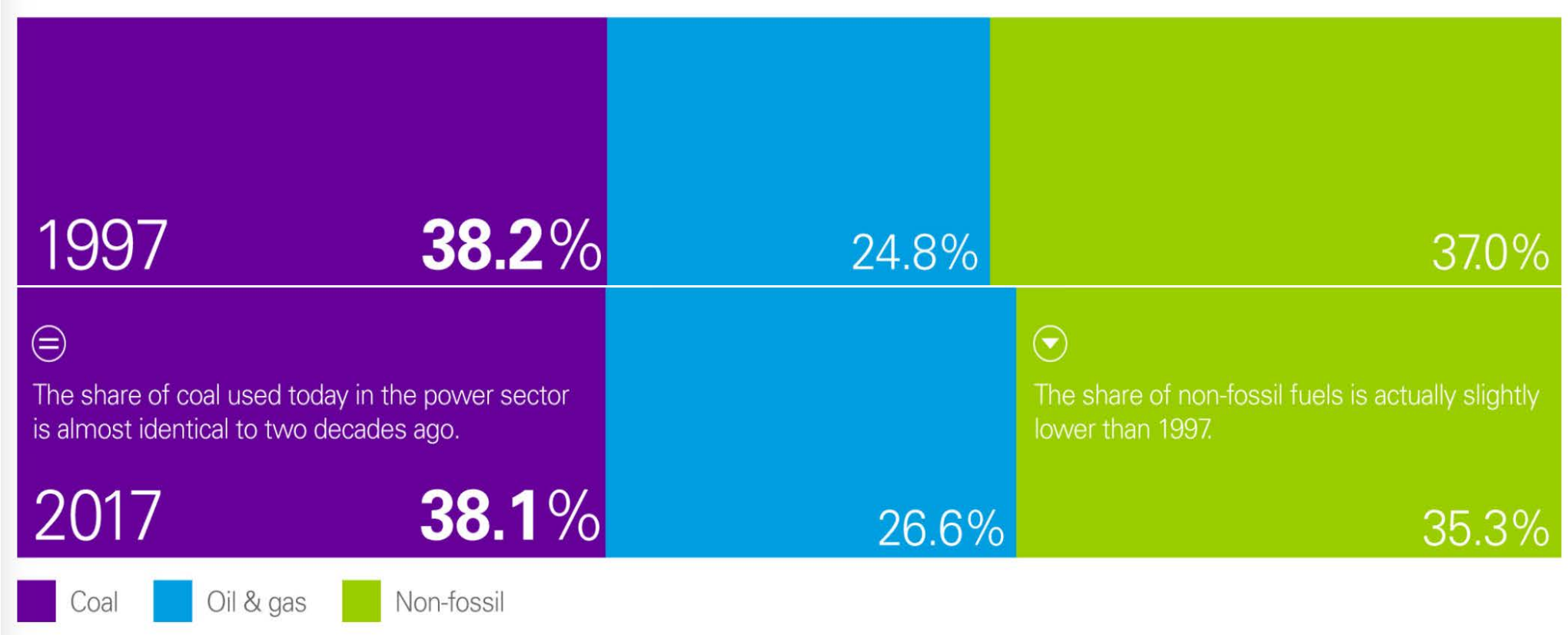


https://yearbook.enerdata.net/electricity/electricity-domestic-consumption-data.html

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.

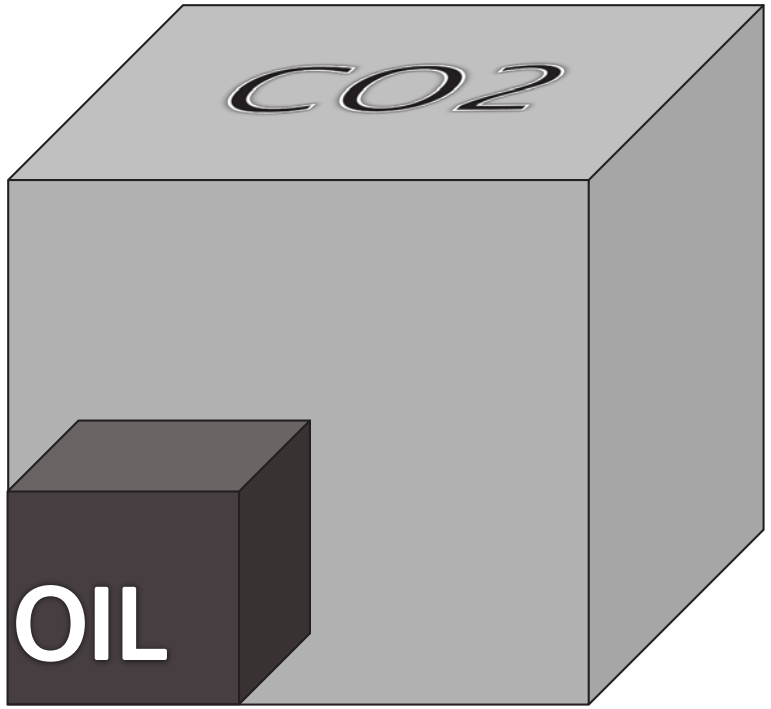
Capture all 37 Gt/yr CO_2 emissions annually

Compress to critical point (73.82 b)

79.2 bn m^3 = cube of side 4.3 km.

World oil production is 3.88 Gt/yr

4.52 bn m^3 = cube of side 1.7 km.



After example by Richard Darton, Oxford

Business opportunity for maritime industry injecting supercritical CO_2 in deep rock reservoirs for storage

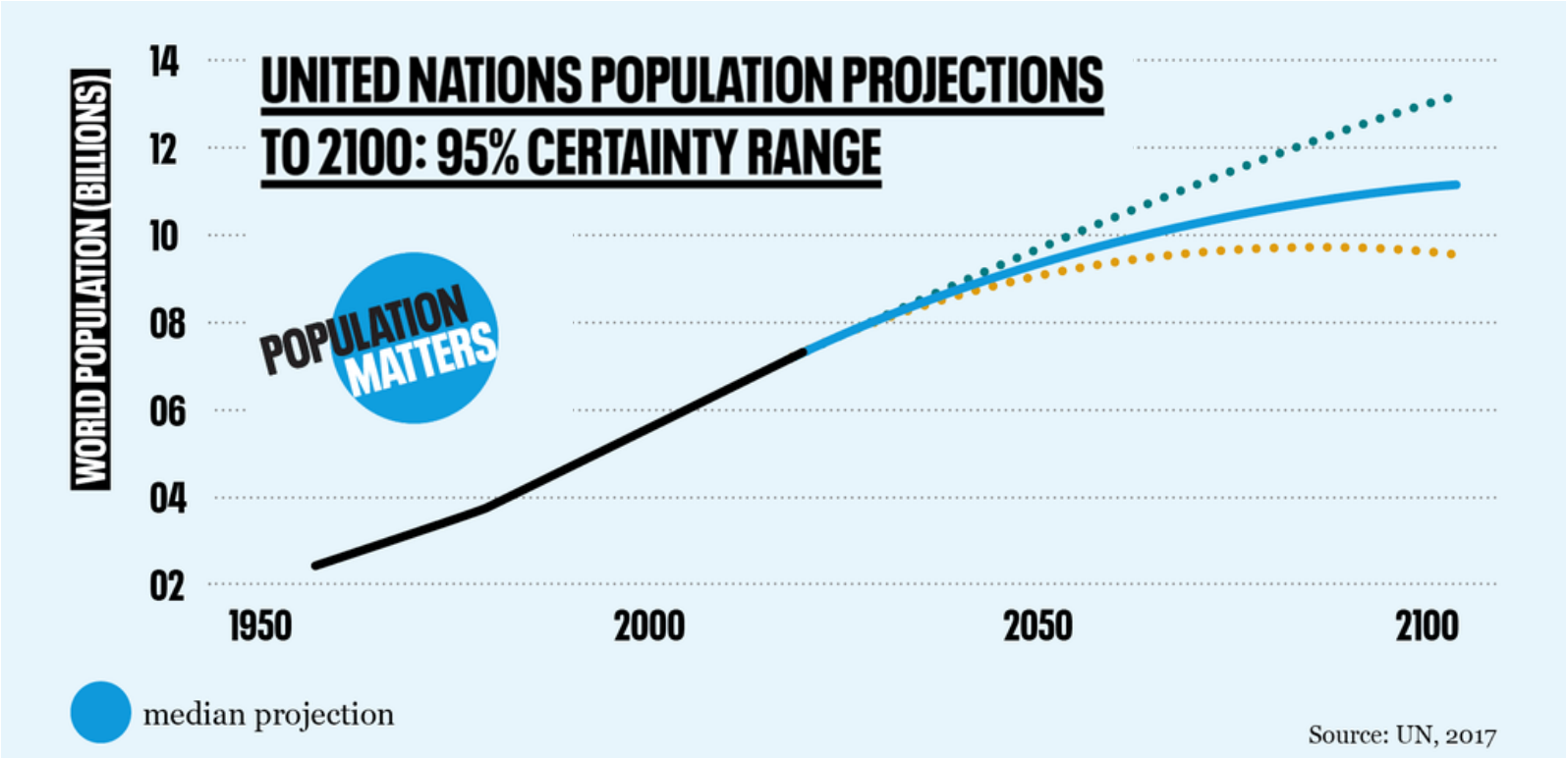
THINKING BIGGER

How else can the maritime sector contribute to clean growth?

University of Southampton

Aquaculture

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



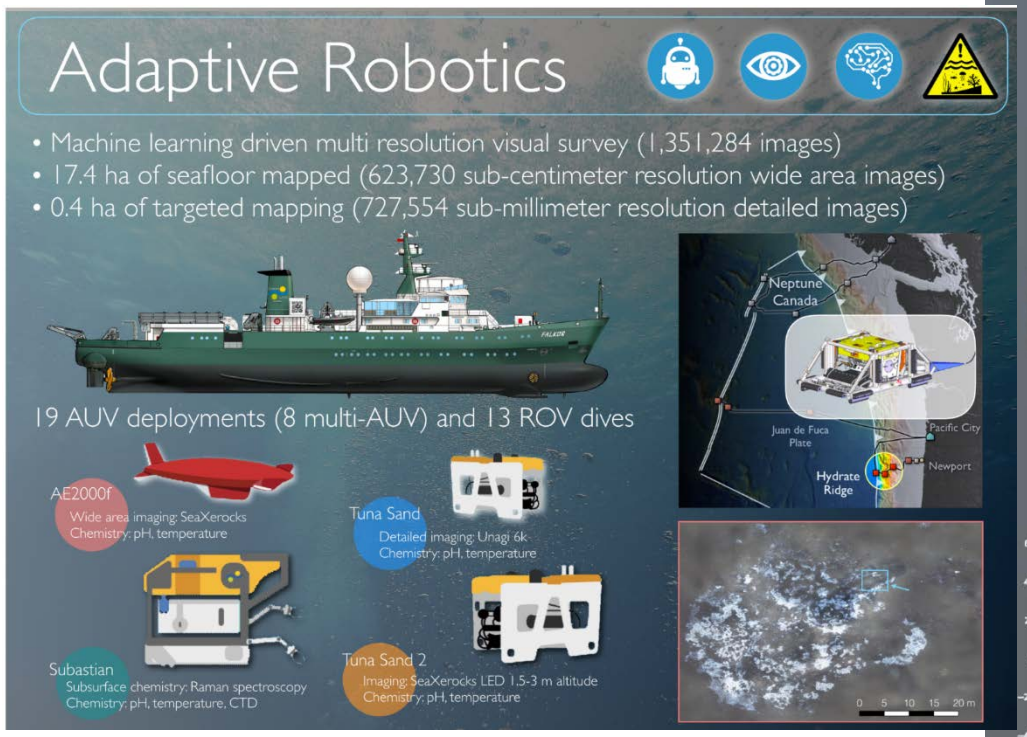
Business opportunity for maritime industry in development of aquaculture

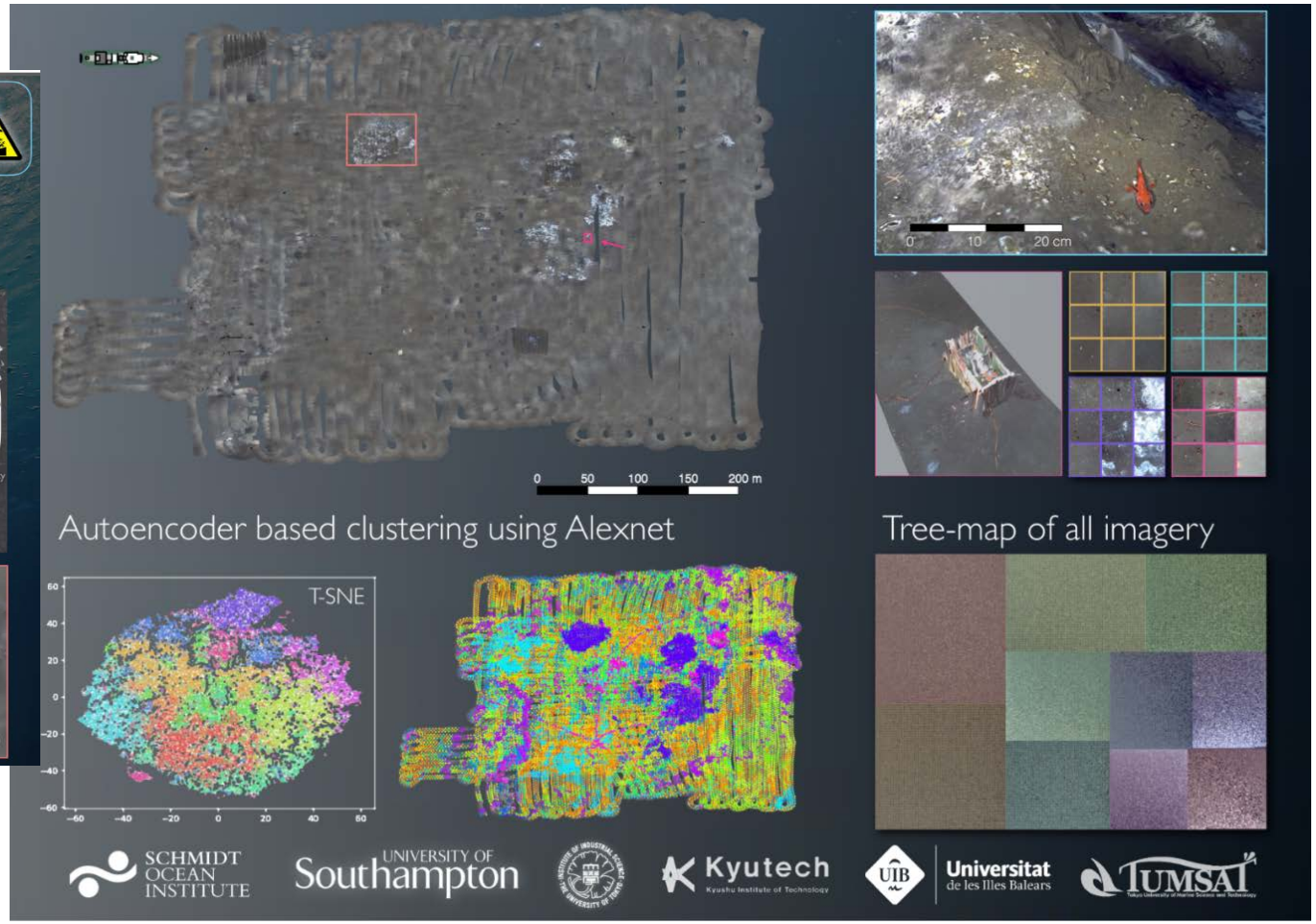
http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf

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.

‘THE’ ENVIRONMENTAL CHALLENGE

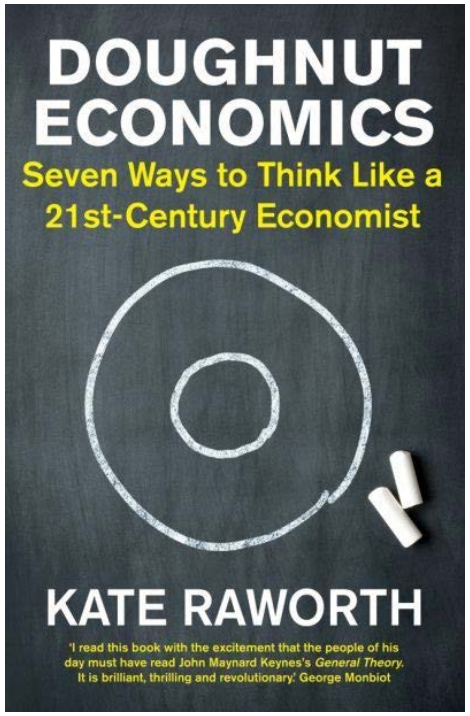
Demand and Limit

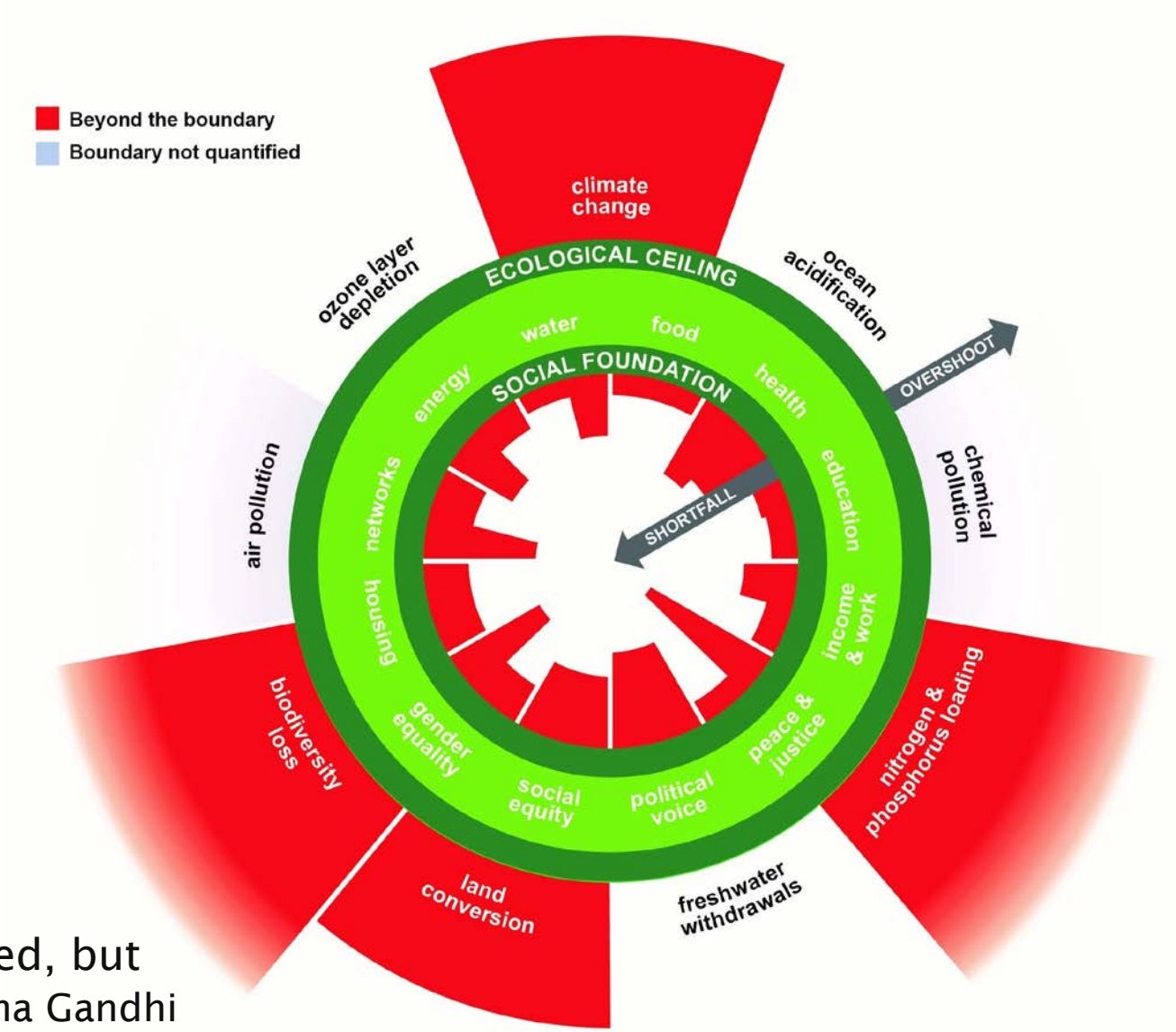
- Demand on the planet – Increased demand for resources, food, goods, energy for an increasing and increasingly wealthy global population pushing outwards
- Limit of the planet – Emissions limits and targets set by legislation or sense of environmental responsibility pushing inwards
- How to reconcile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

‘THE’ ECONOMIC MODEL TO MEET ‘THE’ ENVIRONMENTAL CHALLENGE

Dougnuts – 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

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