Environmental Assessment of the Global Shipping Fleet

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NTNU Industrial Ecology
Norwegian University of Science and Technology

SMART MARITIME

Interdisciplinary Collaboration is Essential

NTNU Industrial Ecology

NTNU OCEANS

NTNU SUSTAINABILITY

ENV

TECH

ECN

NTNU Department of Marine Technology
SINTEF Maritime

Interdisciplinary Collaboration is Essential

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State-of-the-art technologies, measures, and potential for reducing GHG emissions from shipping – A review

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Energy Policy 39 (2011) 3456–3464
Contents lists available at ScienceDirect
Energy Policy
journal homepage: www.elsevier.com/locate/enpol

Reductions in greenhouse gas emissions and cost by shipping at lower speeds

Haakon Lindstad [a,b,*], Bjørn E. Asbjørnslett [a], Anders H. Strømman [a]
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Maritime Policy & Management
The flagship journal of international shipping and port research
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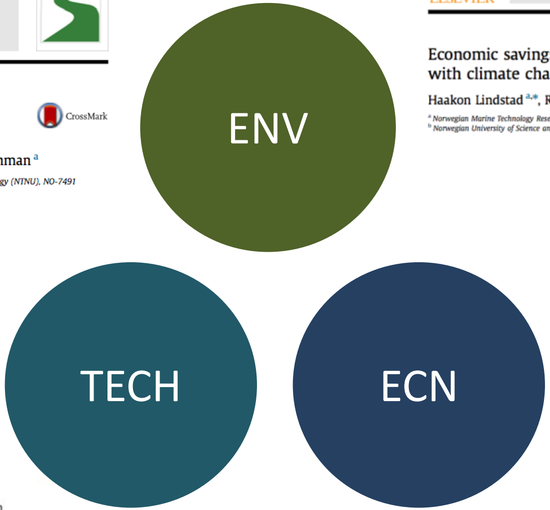
Opportunities for increased profit and reduced cost and emissions by service differentiation within container liner shipping

Haakon Lindstad, Bjørn Egil Asbjørnslett & Anders H. Strømman



Transport Policy 45 (2016) 24–30
Contents lists available at ScienceDirect
Transport Policy
journal homepage: www.elsevier.com/locate/tranpol

Economic savings linked to future Arctic shipping trade are at odds with climate change

Haakon Lindstad [a,*], Ryan
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[b] Norwegian University of Science and Techn

Energy Policy 46 (2012) 386–398
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Energy Policy
journal homepage: www.elsevier.com/locate/enpol

The importance of economies of scale for reductions in greenhouse gas emissions fr

Haakon Lindst
[a] Norwegian University of
[b] Norwegian Marine Tech

Transportation Research Part D 38 (2015) 41–48
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journal homepage: www.elsevier.com/locate/trd

Assessment of cost as a function of abatement options

Ocean Engineering 110 (2015) 94–101
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journal homepage: www.elsevier.com/locate/oceaneng

Maritime shipping and emissions: A three-layered, damage-based approach

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NTNU

SMART MARITIME

sfi = Centre for Research-based Innovation

The Research Council of Norway

Duration: 2015-2023

Budget: 20 MEUR

- **WP 1** Feasibility studies
- **WP 2** Hull and propeller optimization
- **WP 3** Power systems and fuel
- **WP 4** Ship system integration and validation
- **WP 5** Environmental and economic due diligence

Smart Maritime Partners

SMART MARITIME

sfi Senter for forskningsdrevet innovasjon

RESEARCH ORGANISATIONS

SINTEF Ocean

NTNU

DESIGN, EQUIPMENT, SHIP BUILDERS

Rolls-Royce

ABB

HAVYARD

JOTUN

WÄRTSILÄ

SIEMENS

VARD™ a Fincantieri company

norwegian electric systems

SHIP OPERATORS

Wilh. Wilhelmsen

Solvang ASA

GRIEG STAR

KRISTIAN GERHARD JEBSEN SKIPSREDERI
PART OF THE KRISTIAN GERHARD JEBSEN GROUP

OTHER PARTNERS

DNV·GL

Kystrederiene

Norges Rederiforbund
Norwegian Shipowners' Association

Sjøfartsdirektoratet
Norwegian Maritime Authority

Carbon Lock-In

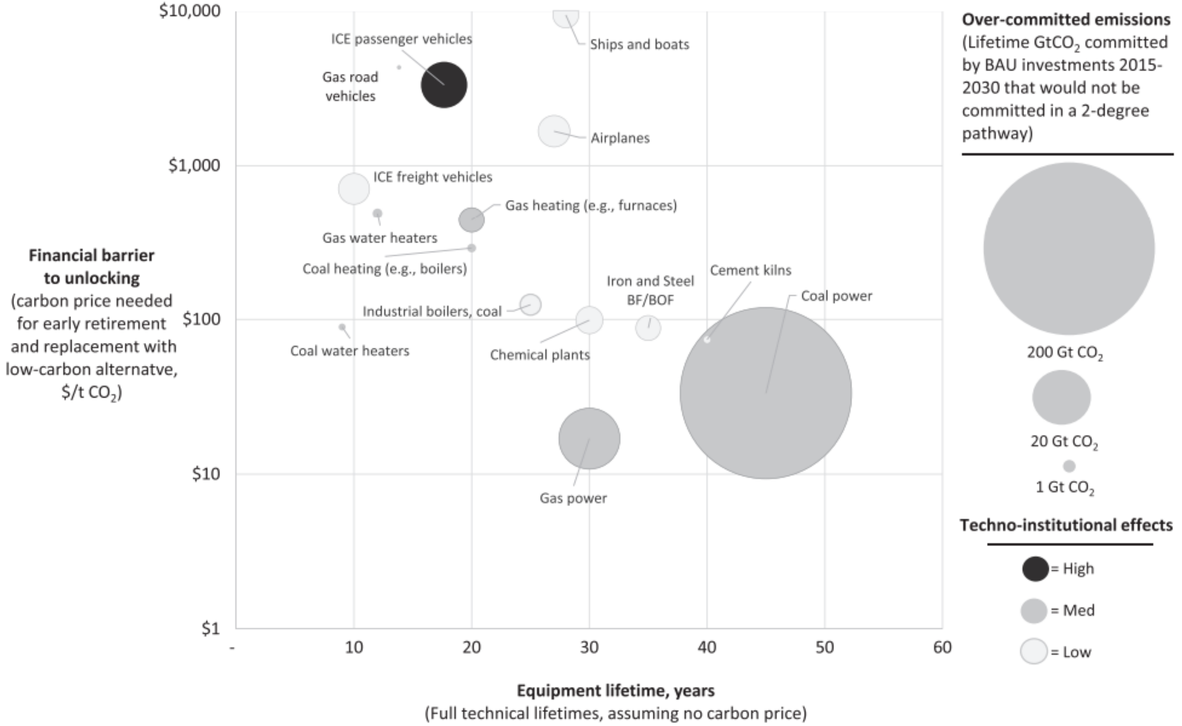


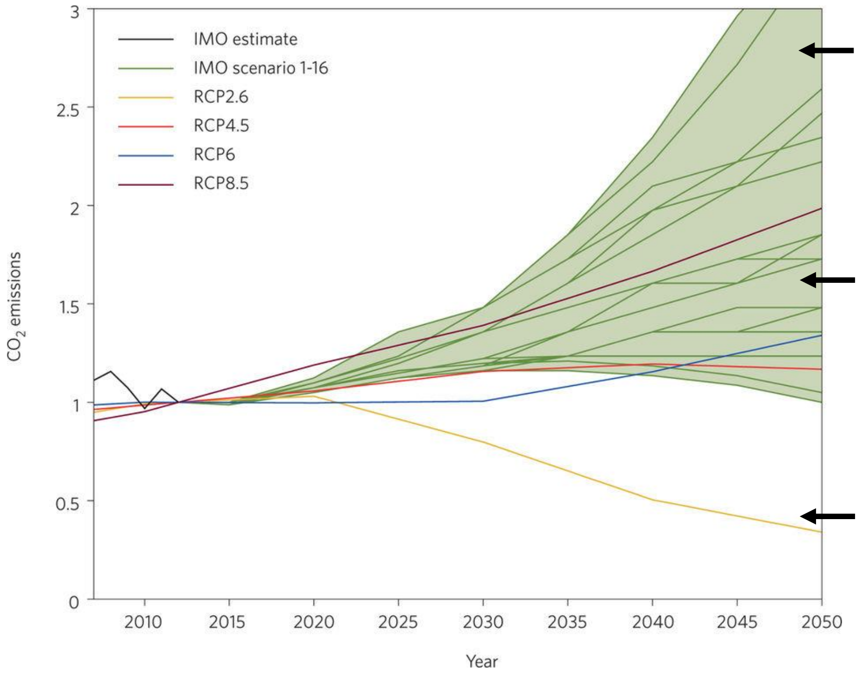
Figure 1. Global assessment of carbon lock-in risks by fuel and sector.

Erickson et al. (2015) Environ. Res. Lett. 10

Future Projections

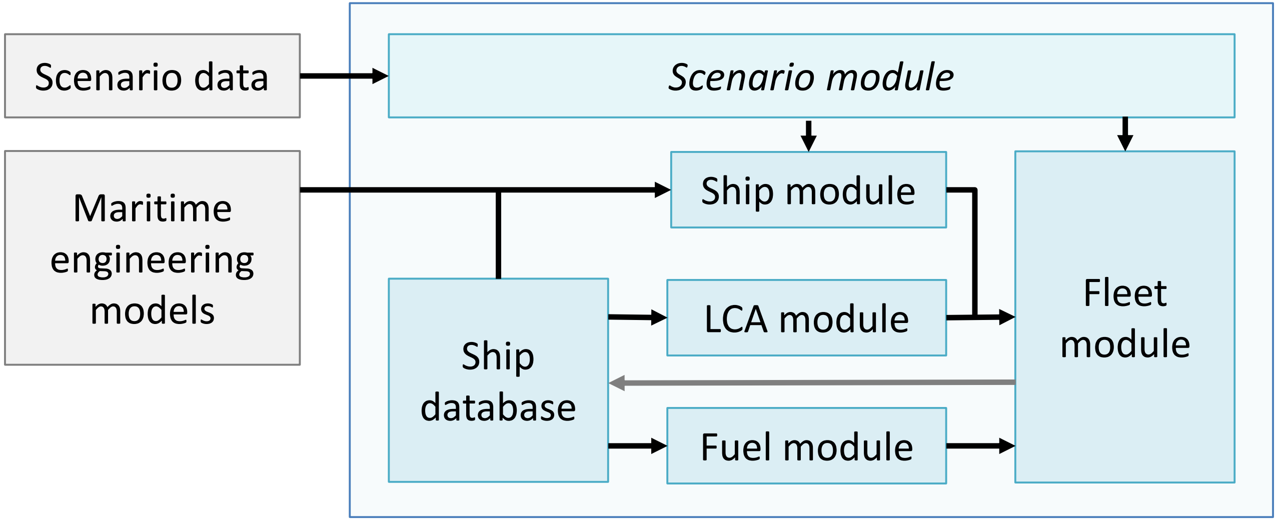
- Impacts of shipping are expected to grow significantly over the coming decades
- Historic sea freight growth from 1970-2012 is 3% annually
- Added back-of-the envelope estimations

- 85% reduction in CO_2/tkm to reach a 2-degree Celsius target



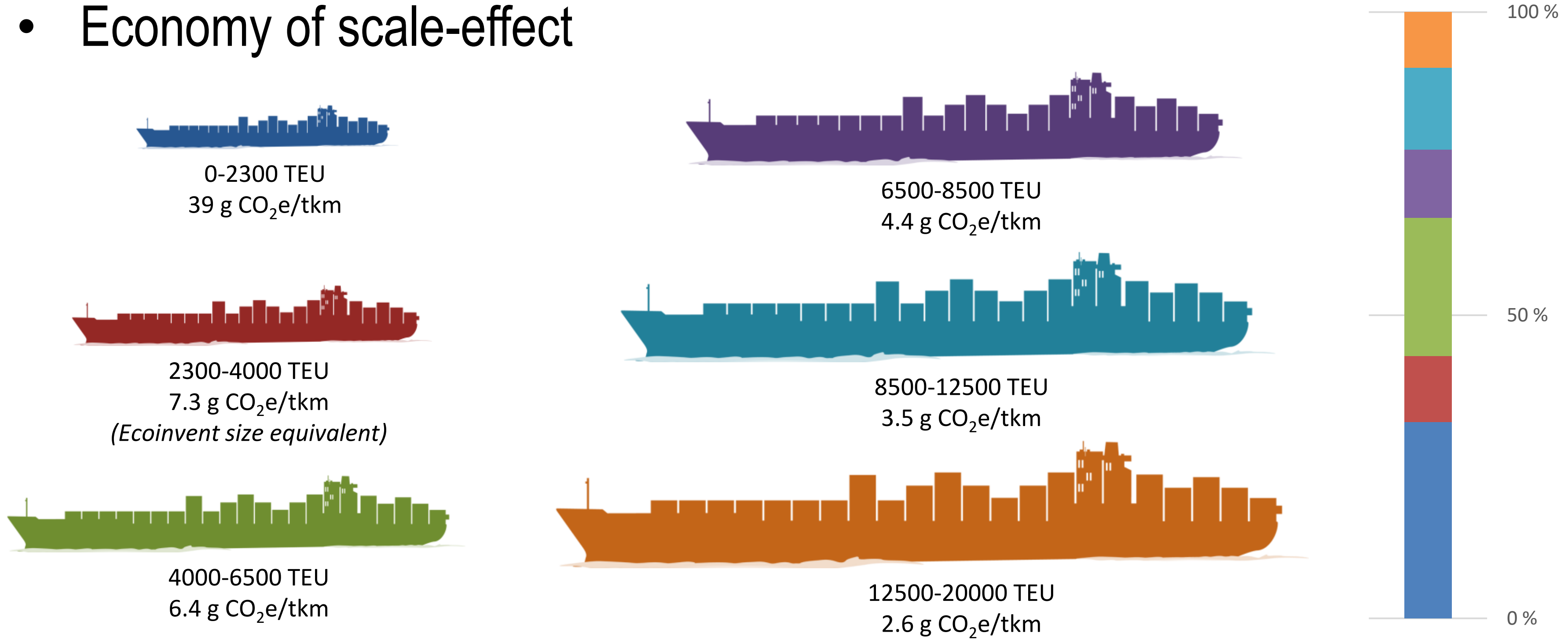
Bows-Larkin et al. (2015). Nat. Clim. Chang. 5a pp 293-295
Anderson et al. (2012) Carbon Management 3 pp 615-629

MariTEAM model

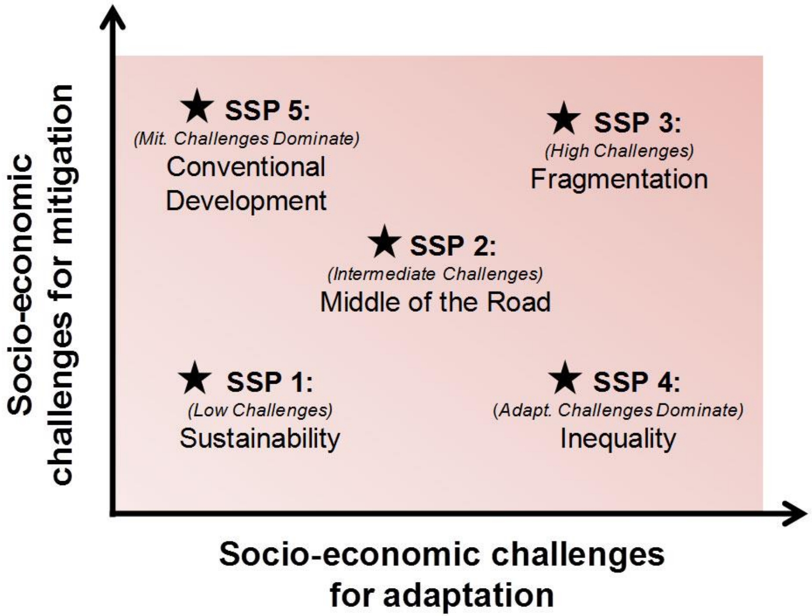


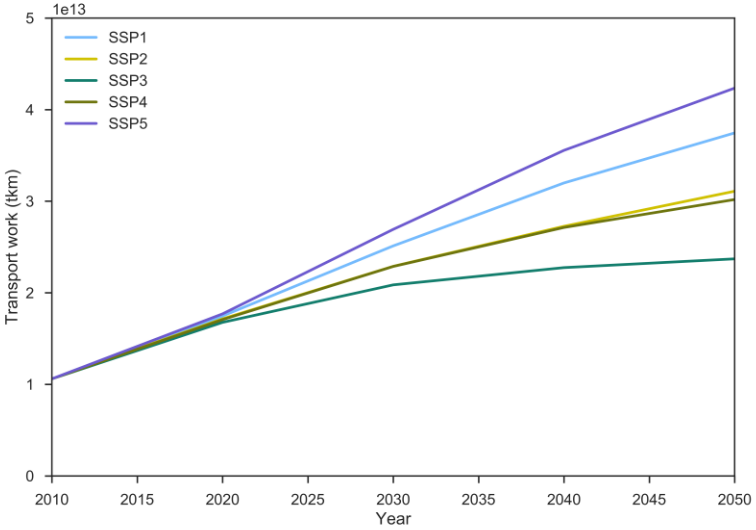
Results for the Containership Fleet in 2016

- Economy of scale-effect

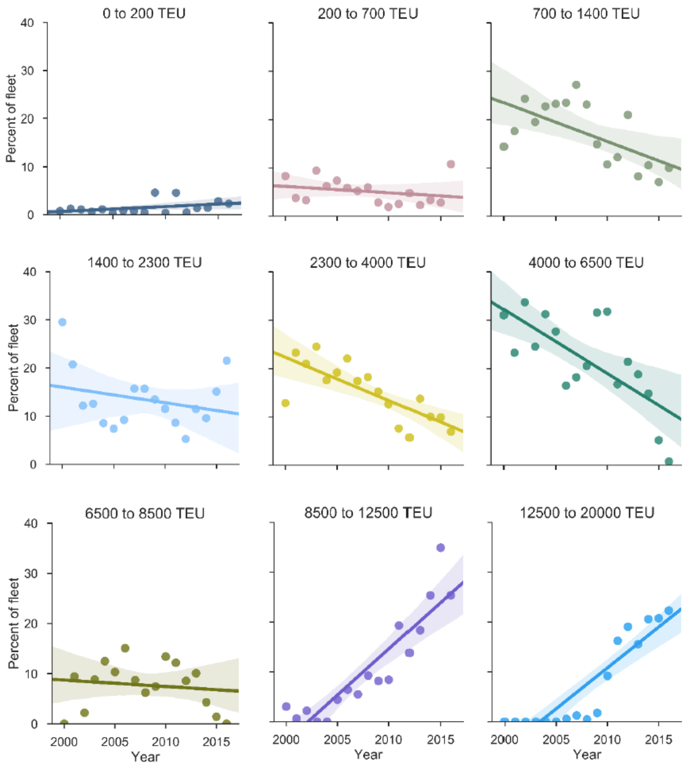


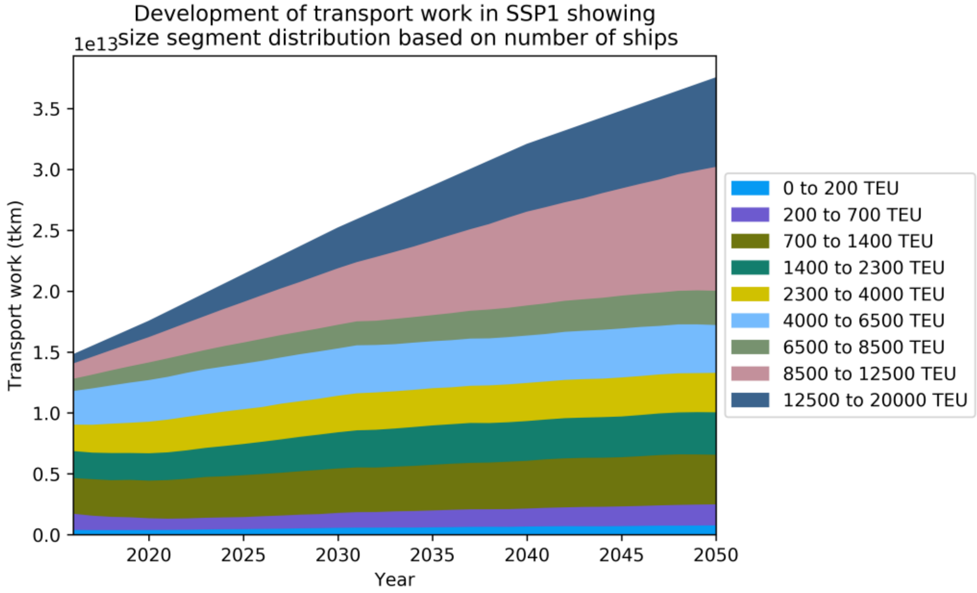
Designing Shipping Scenarios Aligned with the Shared Socioeconomic Pathways (IPCC)



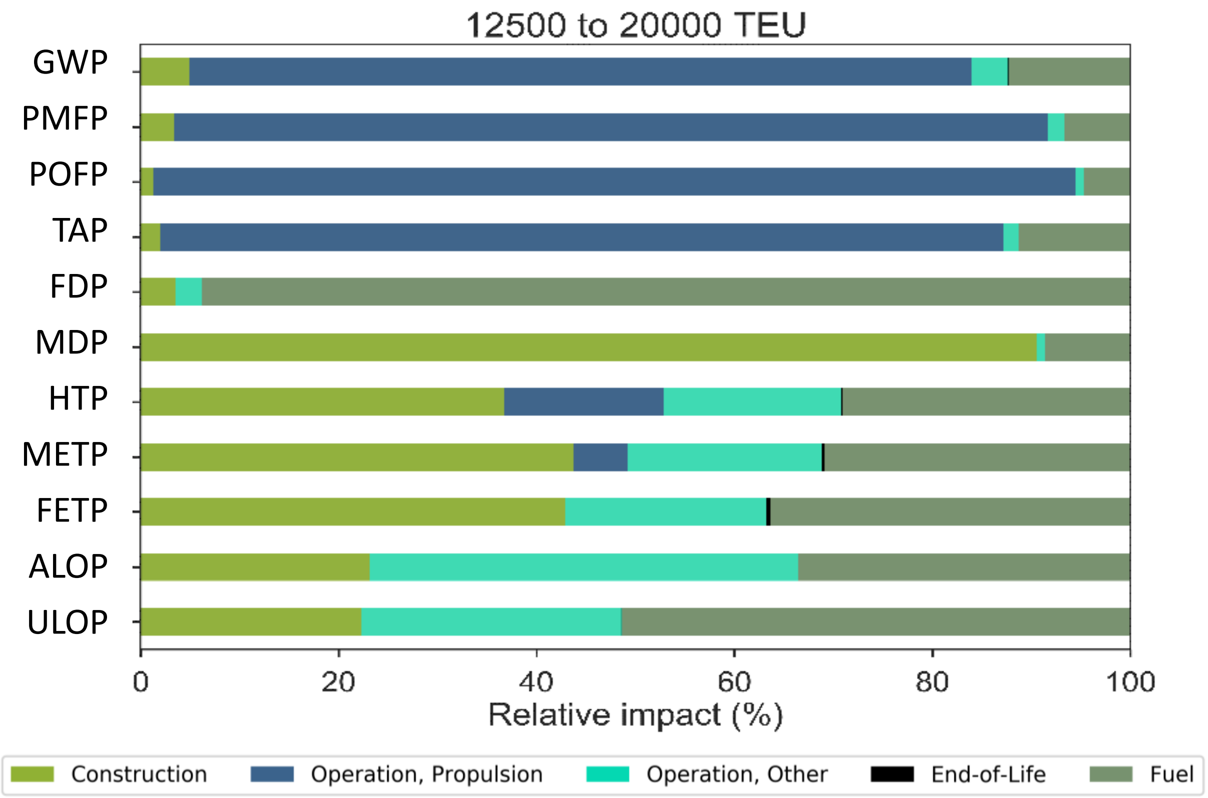


Historic Fleet Data Inform Scenarios for Different Segments





LCA Results

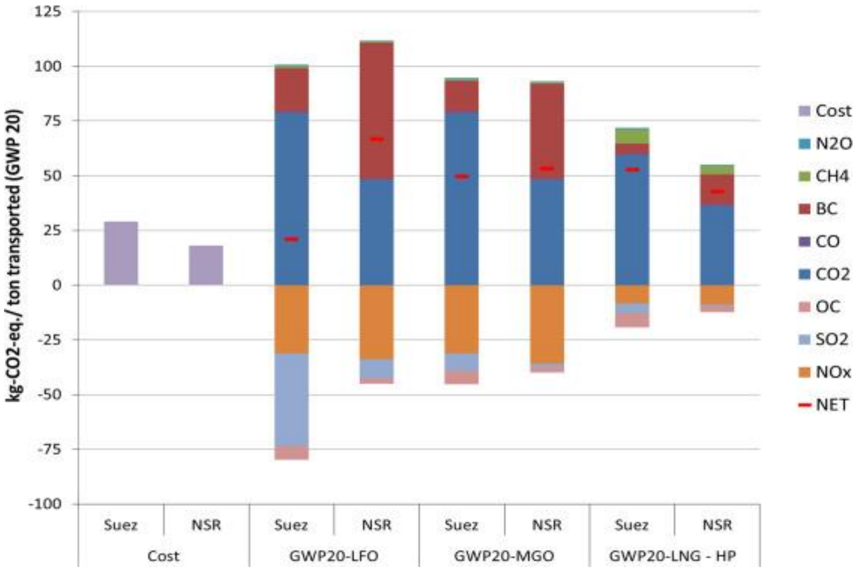

12500 to 20000 TEU
GWP
PMFP
POFP
TAP
FDP
MDP
HTP
METP
FETP
ALOP
ULOP
0
20
40
60
80
100
Relative impact (%)
Construction
Operation, Propulsion
Operation, Other
End-of-Life
Fuel

Location Affects the Climate Impacts of Emissions

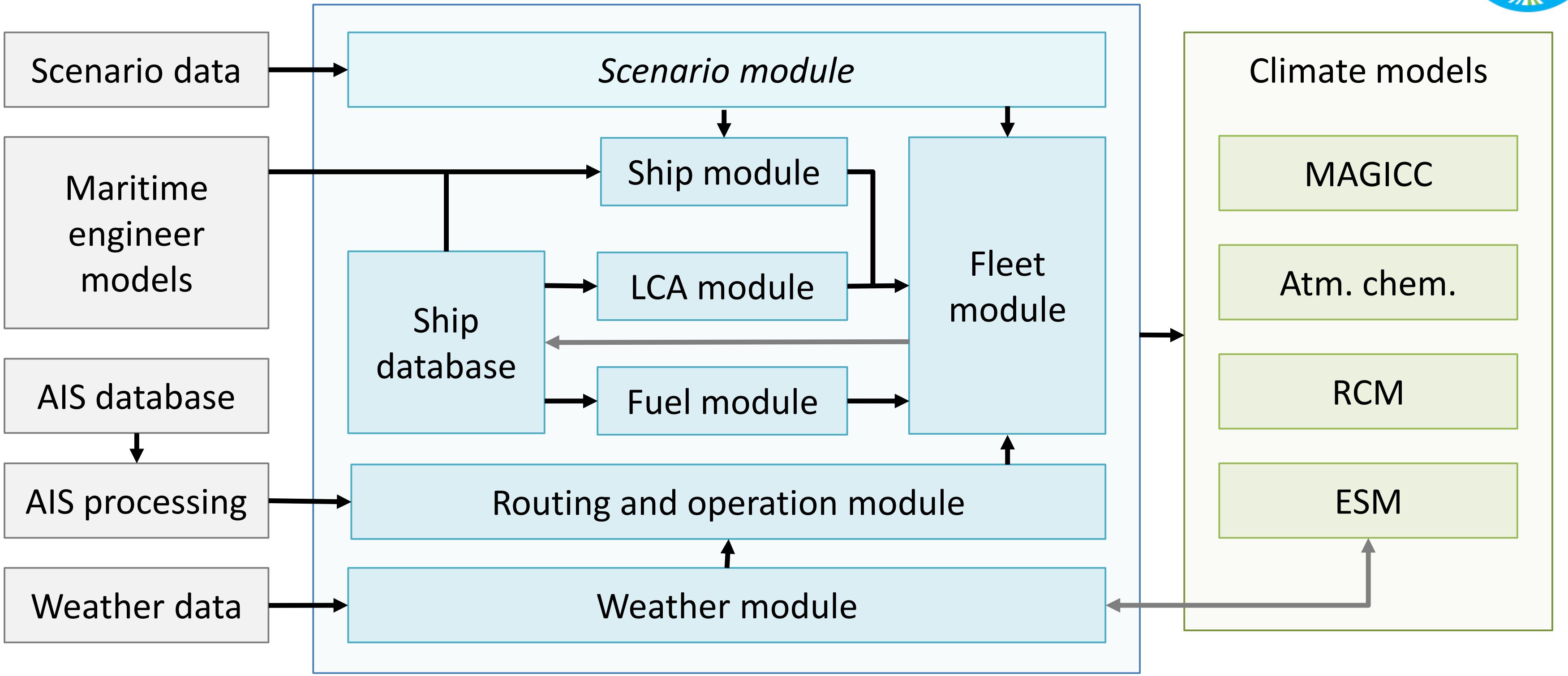
Table 3
Global Warming Potential (kg-CO_2-equivalents/kg emission).

Emission type	CO_2	BC	CH_4	CO	N_2O	NO_x	SO_2	OC
GWP_{20} world factors	1	1200	85	5.4	264	−15.9	−141	−240
GWP_{20} Arctic factors	1	6200	85	5.4	264	−31	−47	−151
GWP_{100} world factors	1	345	30	1.8	265	−11.6	−38	−69
GWP_{100} Arctic factors	1	1700	30	1.8	265	−25	−13	−43

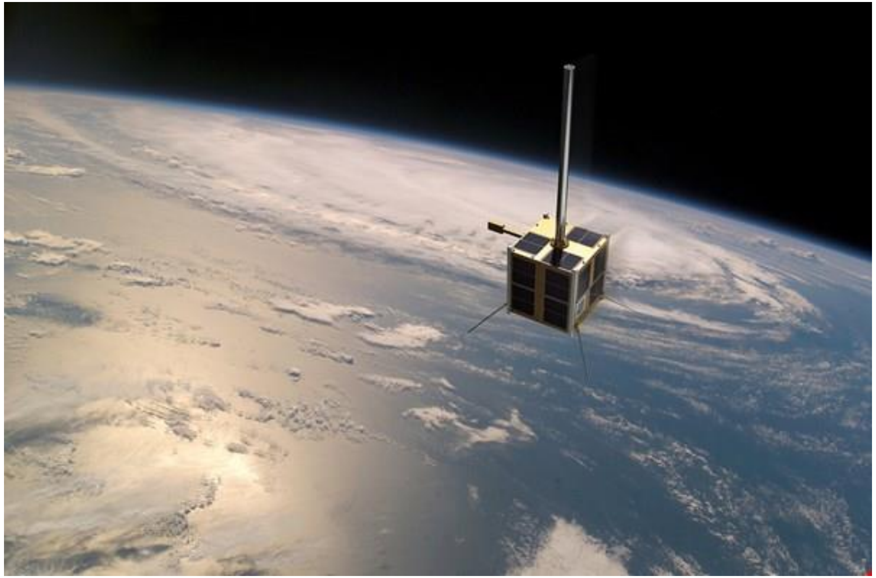
Negative values shown in Table 3 have a cooling effect and positive has a warming effect.

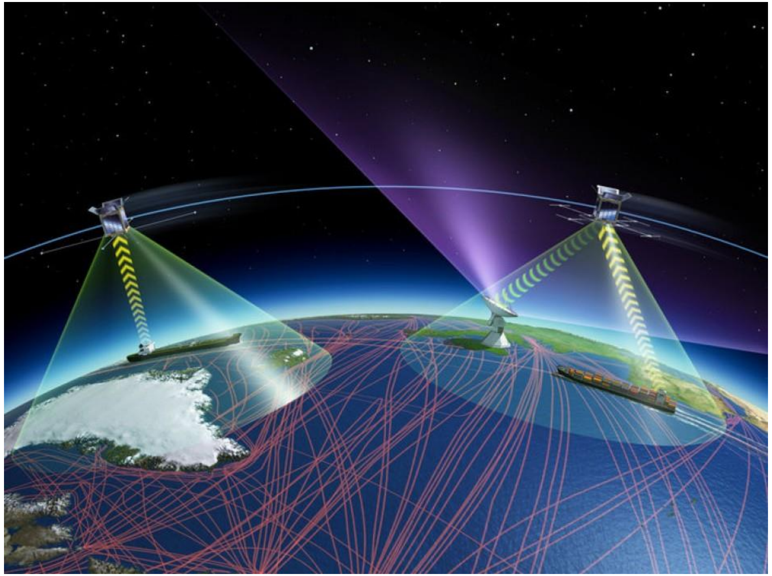


MariTEAM model



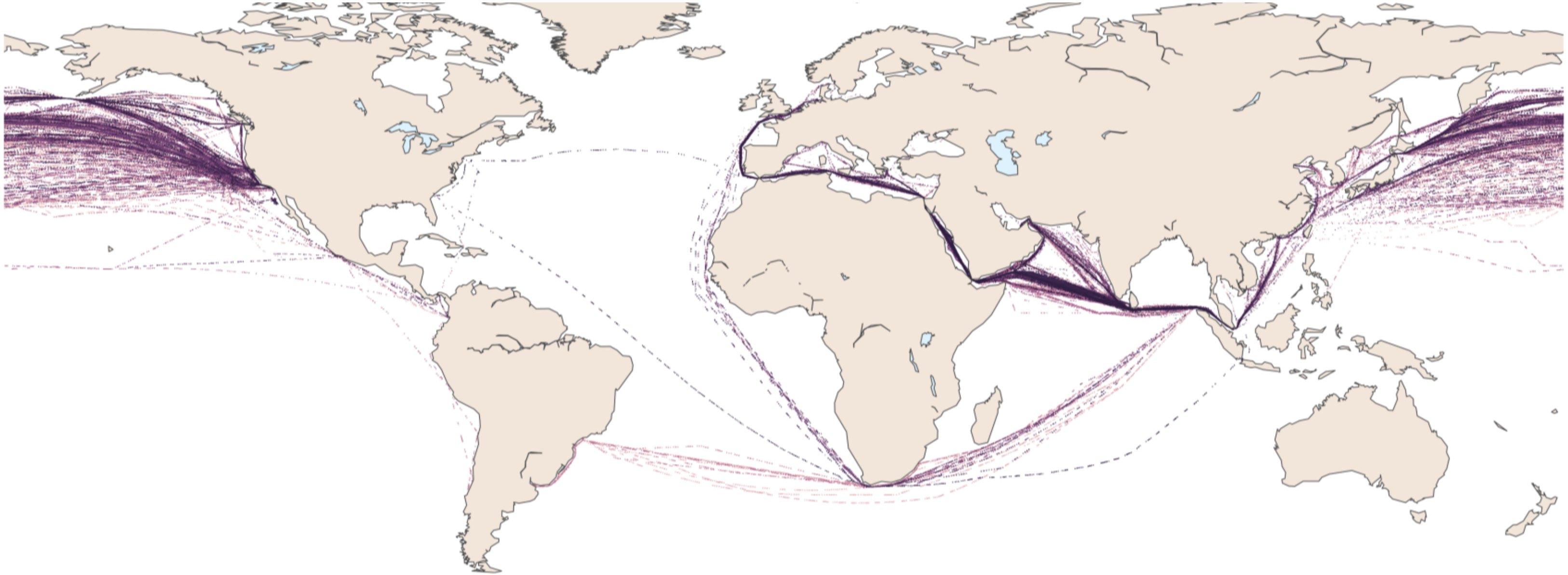
AISsat 1 & 2 Data Covers Global Fleet





Kystverket (2015), kystverket.no
European Space Agency (2016), esa.int

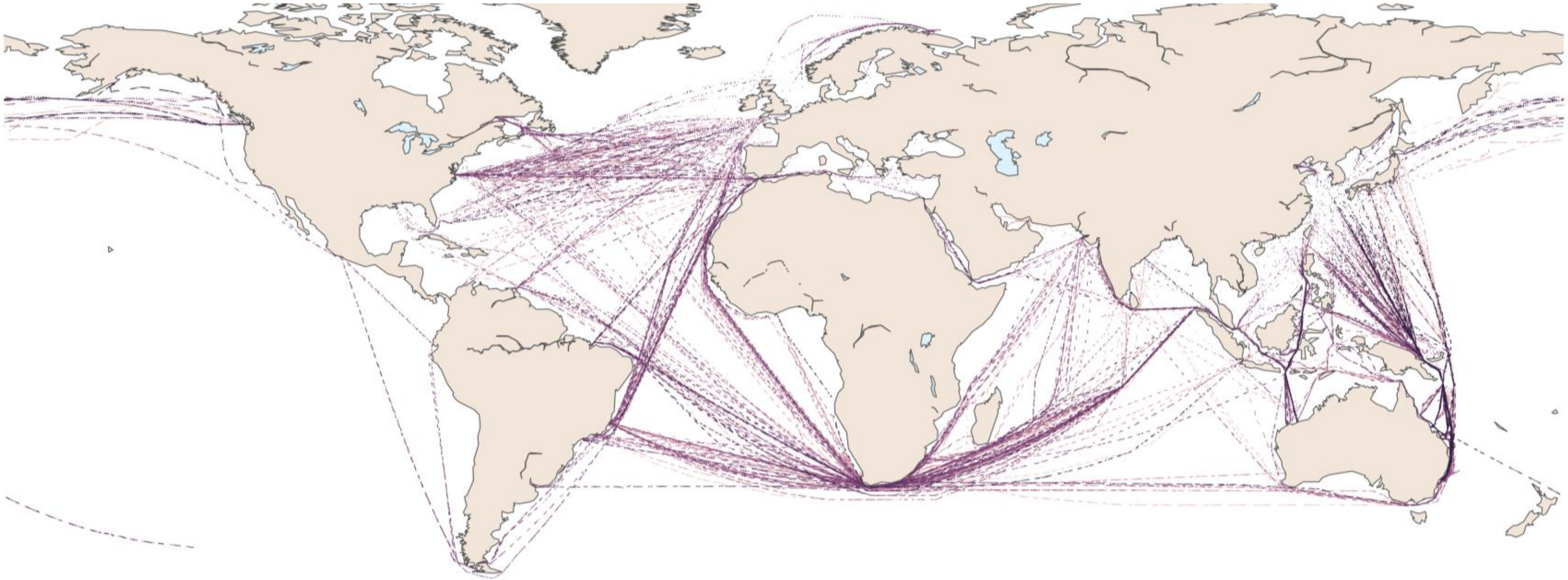
Containership traffic in 2015



Ships built in period 2000-2015 with TEU between 10,000 and 20,000
323 individual tracks in database

AIS messages from Norwegian Coastal Administration (Kystverket) 2015

Bulk carrier traffic in 2015



Carriers built in period 2010-2015 with dwt between 100 and 150 kton
101 individual tracks in database

 AIS messages from Norwegian Coastal Administration (Kystverket) 2015

Collaboration Strategy

Global Transition Pathways

IAMs

- All sectors
- Energy
- Fuels

NTNU Energy Transition program

Maritime Segment

Global, regional and local transition pathways

MariTEAM

- Ship technology
- Marine fuels

NTNU IndEcol
NTNU Maritime
Sintef Ocean

Environmental Pathways

Environmental models

- Climate
- Air pollution
- Biodiversity

NTNU IndEcol