GREENING THE BLUE:
- CHALLENGES AND SOLUTIONS IN THE ENERGY SUSTAINABILITY SHIFT IN THE MARITIME SECTORS

Thor Øivind Jensen
Agnete Hessevik
University of Bergen
OUR STANDARD THEORY (GEELS) FOR TECHNOLOGICAL SHIFT

-Multi-level

- **Niches** of new alternatives, small and protected and experimental
  - State support in development important (Mazzucato)
  - Often regime power tries to keep the niches in their niche place

- **Regimes** are the dominating technology with all its material and cultural subsystems
  - In shipping: the slow-turning 2-stroke diesel on heavy fuel

- **Landscape** is the total social environment that surrounds the sector, including culture and general social patterns
  - The general pressure from UN/ICCP and the general public is important for our case

HOW CAN MORE SUSTAINABLE NICHE TECHNOLOGIES GROW INTO NEW REGIMES IN THE DIFFERENT SHIPPING SECTORS?
The maritime sector at large is old, mature, powerful, institutionalized, self-governed and only to a small degree regulated from national state level. It is strongly path dependent and likely to not change fast or respond easy to external pressure, *(see: Pettit et al 2017)*

Still, as the following 16 pictures show, most subsectors have started a change, showing some niche technologies growing, with very different speed, in the direction of new and more sustainable low-emission technological regimes.

Why? And will it really be new regimes or stay as nice and small niches? Can we sort out some driving governing mechanisms?
ELECTRICAL FROM 1894, AND AGAIN FROM 2015, LOCAL CROSS-HARBOUR
RETROFITTING SCRUBBERS (2016→) AND REBUILD TO BATTERY HYBRID (2019→) BECOMES POPULAR
ELECTRICAL COSTAL FISHING BOAT-2015-→
ELECTRICAL LOCAL CAR FERRY 2015 (NOW: 70 BUILDT OR UNDER CONSTRUCTION IN NORWAY)
TOURIST SIGHTSEEING HIGH SPEED, HYBRID-2017 FULLY ELECTRICAL-2018
ELECTRICAL LEISURE BOATS - ON THE MARKET 2018
SUPPLY-SHIPS IN OIL SECTOR GOES HYBRID (2018-7 SHIPS)
HYBRID INTERNATIONAL POLAR CRUISE SHIP -2019
COASTAL LINER, BIOGAS + BATTERY (2020)
MORE HYBRID CRUISE SHIPS-2021 (TICKETS ON SALE)
Greece's Port of Killini, at the west side of the country towards the Ionian Sea, is to see the first shore-to-ship (STS) electrical supply connection in Eastern Mediterranean. The Ro-pax ferry 'Fior Di Levante' will plug into the region's first shore power facility, in a special inauguration ceremony on Thursday, 20th December 2019.
INLAND BARGES FOR CONTAINERS - BATTERY POWERED -
NETHERLANDS 2019
ELECTRICAL, DRIVERLESS, COASTAL (2026)
AND THE BIG LONG-HAUL CARRIERS: 
THE GREAT TECHNOLOGICAL AND 
GOVERNANCE CHALLENGE

- Ony 16 of these can pollute as much as all cars in the world (Sulphur )
- IMO reduction plans 1997, 2018 (50% CO2-reduction in 2050)
- 0.5% sulphur form 2010: Removing pollution (scrubbers). Rapidly growing (scrubber companies are growing fast, like 1000% in 3 yrs)
- International shipping and aviation are not in the Kyoto Protocol rules on cutting carbon emissions. Nation state governance is weak, international governance is based on sets of organizations, market based and membership based
- Both experience and forecasting point to fuel price sensitivity. Slow speed reduces CO2 and are chosen if fuel is expensive
- Forecasting gives us 50-250% growth due to economic growth, low alternatives if world economy cools down (Trump !) or a sustainable path is chosen. (CE Delft2017, NB this report is not taking tech change into consideration)
# Our Categories of Shipping

<table>
<thead>
<tr>
<th>Category</th>
<th>Long-distance carrier</th>
<th>Long-distance pass (cruise)</th>
<th>Regional (supply ships) and fishing</th>
<th>Regional pass/tourism/ferry</th>
<th>Short (fixed) distance ferries and passenger</th>
</tr>
</thead>
</table>

Left out: Leisure boats, ocean fishing, barges, regional freightships
# The Analytic Framework

<table>
<thead>
<tr>
<th>Category</th>
<th>Int Carrier</th>
<th>Int Cruise</th>
<th>Supply/fishing</th>
<th>Regional pass</th>
<th>Short distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tech challenge</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Org/Pol governance pattern</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maturing sosio-tech solution</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Governance tolls for change</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## The Analytic Matrix

<table>
<thead>
<tr>
<th>Category</th>
<th>Int Carrier</th>
<th>Int Cruise</th>
<th>Supply/fishing</th>
<th>Regional pass</th>
<th>Short distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tech challenge</td>
<td><em>High, Energy density, global fuel access</em></td>
<td><em>High, Energy density, High energy needs, Onshore Power</em></td>
<td><em>Low, Variable needs,</em></td>
<td><em>Medium, Energy density, safety, Infrastructure, onshore Power, energy source</em></td>
<td><em>Low, Infrastructure</em></td>
</tr>
<tr>
<td>Org/Pol governance pattern</td>
<td><em>Polycentric, Self-governance, International, (IMO,EU) juridistiction challenge</em></td>
<td><em>Polycentric, Self-governance, sector organization, International</em></td>
<td><em>National and semi-national, oil sector power</em></td>
<td><em>National, semi-national and port juridistiction.</em></td>
<td><em>National, regional</em></td>
</tr>
<tr>
<td>Maturing socio tech solution</td>
<td><em>LNG, Biofuel, Hydrogen, ammonium, Methanol</em></td>
<td><em>Battery hybrid, LNG, biofuel</em></td>
<td><em>Battery Hybrid, hydrogen</em></td>
<td><em>Battery, Hybrid, LNG, biofuel, hydrogen</em></td>
<td><em>Full battery, hydrogen</em></td>
</tr>
<tr>
<td>Governance tools for change</td>
<td><em>Int sector (IMO,EU) regional (ECA), port, indirect consumer, Normative,</em></td>
<td><em>Consumer direct, regional (ECA), port reg, Normative, Networks, Financial</em></td>
<td><em>Governmental regulation/support Sector networks, procurement, Cost sharing</em></td>
<td><em>Consumer, Port, national regulation, regional (ECA), Financial, Environmental org</em></td>
<td><em>Public regulation + procurement. Cost sharing, Environmental org, Networks including</em></td>
</tr>
</tbody>
</table>

- **Tech challenge**
  - High, Energy density, global fuel access
  - High, Energy density, High energy needs, Onshore Power
  - Low, Variable needs,
  - Medium, Energy density, safety, Infrastructure, onshore Power, energy source
  - Low, Infrastructure

- **Org/Pol governance pattern**
  - Polycentric, Self-governance, International, (IMO,EU) juridistiction challenge
  - Polycentric, Self-governance, sector organization, International
  - National and semi-national, oil sector power
  - National, semi-national and port juridistiction.
  - National, regional

- **Maturing socio tech solution**
  - LNG, Biofuel, Hydrogen, ammonium, Methanol
  - Battery hybrid, LNG, biofuel
  - Battery Hybrid, hydrogen
  - Battery, Hybrid, LNG, biofuel, hydrogen
  - Full battery, hydrogen

- **Governance tools for change**
  - Int sector (IMO,EU) regional (ECA), port, indirect consumer, Normative,
  - Consumer direct, regional (ECA), port reg, Normative, Networks, Financial
  - Governmental regulation/support Sector networks, procurement, Cost sharing
  - Consumer, Port, national regulation, regional (ECA), Financial, Environmental org
  - Public regulation + procurement. Cost sharing, Environmental org, Networks including
GOVERNING WITH SMALL TOOLS: INTERNATIONAL SHIPPING GOVERNANCE

Classic environmental regulation has a command-and-control perspective that is not in the core of how shipping is governed.

The actors (shipowners) have values and social organization, also semi-formalized in networks or organizations.

- Surveys and interviews indicate that they are negative to formal regulation and positive to industrial norms, customer pressure and their own environmental strategy.

The sector is old and have thru the years developed series of private or half-private organizations that govern and support (Classification, insurance). Actually a web of stable and trusted organizations are handling standards, accountability, insurance and more.

-Governing by selfregulation and values can be seen in examples: The reduction of oil spills in the 1990s, but in US and global

-IMO (UN-established, Intergovernmental) have established several environmental regulations (MARPOL) with some empirical success.

- Important IMO decisions since 1997, the 0.5% sulphur from 2020 seem to have great impact and the 2018 decision to reduce with 70% (adjusting for growth =50%) by 2050 is one of the most important governing forces in the years to come.

- Amsterdam is one city to have a policy that requires every commercial ship to be zero-emissions on its canals by 2020 or 2025, depending on its size. California has at-berth restrictions for emissions from trading vessels in the ports of Los Angeles, Long Beach, Oakland, San Diego, San Francisco and Hueneme (IDtechEx Sep 2019)

- Chinese Ports (2017→) Sulphur restriction,

- Singapore: LNG safety standards

- Baltic sea, CO2 restrictions from 2021

- EU emission control areas (ECA’s)

- Norwegian World Heritage Fjords, from 2020 requires low-emission and no release of scrubber wastewater.

- UK Waters from 2025: Must include no-emission technology

- Port regulations (World Port Climate initiative, Green port initiative)

- Requirements for hooking up electricity when in port (cold ironing)
THE FUEL MENU

Traditional (Regime)
- Variants of sulphur (4.5-0.0, %), different implementations, lots of development work for efficiency, incremental, adaptive

BIOFUEL
- Easy to use, but production capacity and political discussions (EU solution?) Biogas better than biodiesel
  - Phase 3 biofuels are circular economy
  - Potential great reduction in calculated CO2 (but calculations are difficult)

LNG
- Reduction in CO2, but indirect release of climate gases. Not difficult in new ships

AMMONIUM
- Potential very small emissions
- Immature technology
- Use existing engine technology

ELECTRICAL/BATTERIES
- Mature technology, Very good in some applications, but very low energy density

HYDROGEN/FUELCELL
- Immature, but in use
  - Promising at the theoretical level, made from water with sustainable energy it is the alternative with lowest CO2 emission
  - Huge change in infrastructure needed
  - Other sources that hydrogen under development (higher security): LNG, diesel, methanol

NB1: With dieselecetric traditional drivetrain a long range of possible hybrid fuelmix and rebuilds are possible, well adapted to switch between energy sources (battery, fuelcell, different engines)

NB2: The sustainablity depends heavily on the original source of energy (Battery, Hydrogen, Ammonium)

(Sources: Bouman et al 2017, Psaraftis et al 2019, DNV/GL 2018)
THE GOVERNANCE MENU

1. Total political governance, (ownership)
2. Public policy framing /a) jurisdiction, b) procurement, c) financial support/
3. Classic regulation /a) national b) international/
4. Regulation (general international, of areas (ports, vulnerable sea areas)
5. Market based institutional regulation (classification, insurance, finance)
6. Sector member organizations
7. Network groups a) inside sector b) spanning sectors
8. Consumer pressure a) direct b) indirect
9. Company culture, leadership
10. Nudging cooperating sectors (banking, investor funds, insurance, classification)

-The Norwegian El-ferry «revolution» have 2a, 2b, 2c, 3a, 6, 7b, 2b and 2c crucial
-International shipping have 3b, 4, 5, 6, 7a, 8, 9, none of them «strong». Crucial are 5, 6, 8, 9
-Coastal fishing and oil supply ships have 3a, 4, 5, 6, 7b
-Networks (7b) can make contacts and span subsectors
-International shipping and ferries have little direct overlap!
THE PRAGMATIC ANSWERS

1. The shipping subsectors that have ready technology niches and strong governance is moving (but fast enough?)
   - Ferries, coastal traffic, fishing and oil sector all have «good niches» of electrical or hybdrid technology
   - In Norway the networks between ferry companies, politics and ship/engine companies are important
   - There are win-win solutions: Speed, efficiency, Onshore power, some hybrid use (fishing, supply), consumer demand pull,
   - Is there a «Creative destruction» in sight? (Schumpeter)

2. International shipping is a long way from rapid change: Both governance and technological problems. Some small trends:
   - Port restrictions, ECAs and IMO decisons are working
   - Scrubbers, sulphur, particles
   - Slow speed and size is a tried way of reducing CO2 emissions (and cost)
   - Consumer pressure in the cruising sector is working
   - Landscape level changes (general climate anxiety) and reputation have influence (Maersk)
   - Incremental changes multi-fuel solutions (for ECAs), flexible engine solutions
   - The ghost from 2050 (IMO decision)
   - Many governance tools are network and people based
   - One of our Norwegian networks are centered around DNV/GL (Int classification company)
HOW TO CREATE CONSUMER PRESSURE IN CRUISING

Small particle emissions on cruise ships per m³

- On deck: 380,000
- On a busy street: 20,000
- In clean air: <2,000

Source: NABU
CONCLUSIONS

1. The maritime sectors are too different in technology and governance and regulative arrangements to be treated within one policy tool or one theory.

2. There are mature technologies for most subsectors (the important heavy long distance still probably a problem, due to energy-density challenge).

3. There are sets of tools that helps rapid transformation in some subsectors, public political ownership/procurement and regulation being the strongest followed by international organizations and consumer demand. Intermediate governing organizations important (insurance, class companies) Some new regulative tools are developed with success (Harbour-based, regional-based).

4. International shipping has a polycentric and internationalized and networked semi-private governing pattern (Furger, Gritsenko, Pettit et al) Networks, self-governance and sector normative factors are important, also for building bridges between subsectors. Our understanding of how governance work in international shipping is not good, traditional governing studies being national state and formally top-down focused. We need more studies of actors, values and networks and how they interact with bits of regulation.
REFERENCES


Vol. 20. No. 5, pp 537-554

Interviews with key actors in 2 Norwegian green maritime networks 2018/19 (Hessevik, forthcoming)