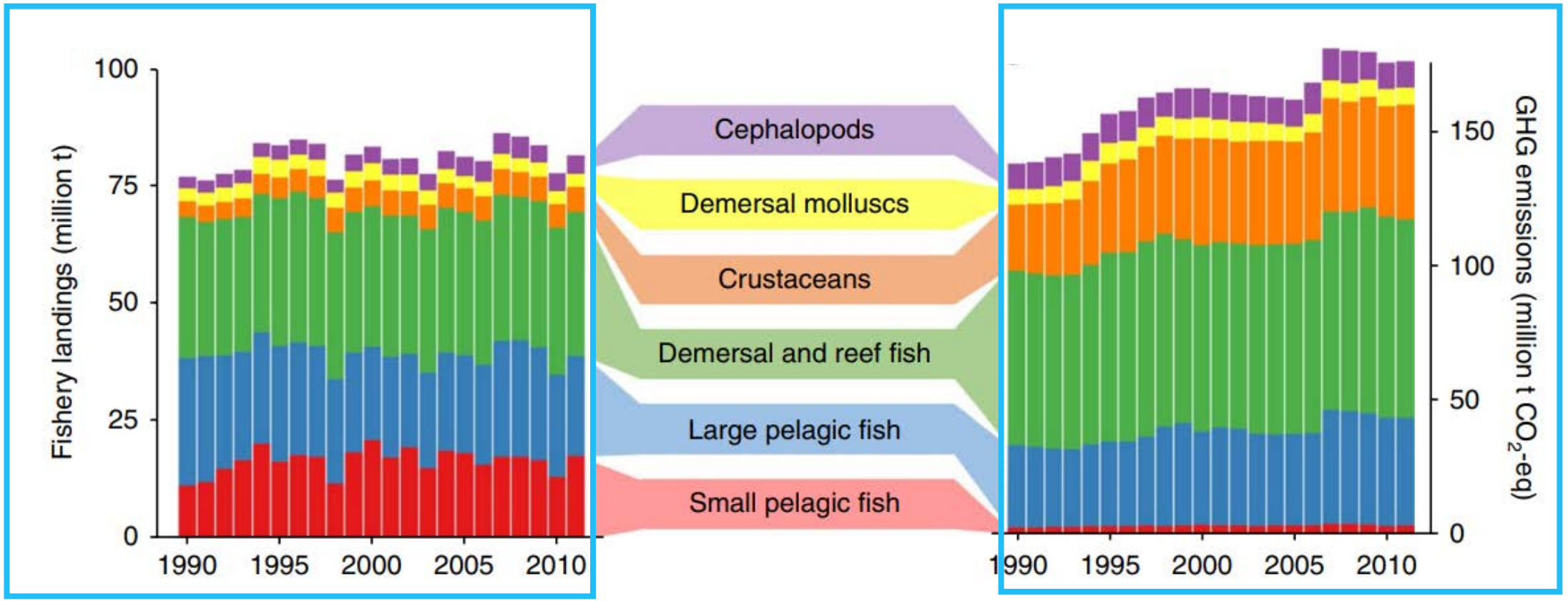


Energieffektivisering og Utslippsreduksjon i Fiskeflåten

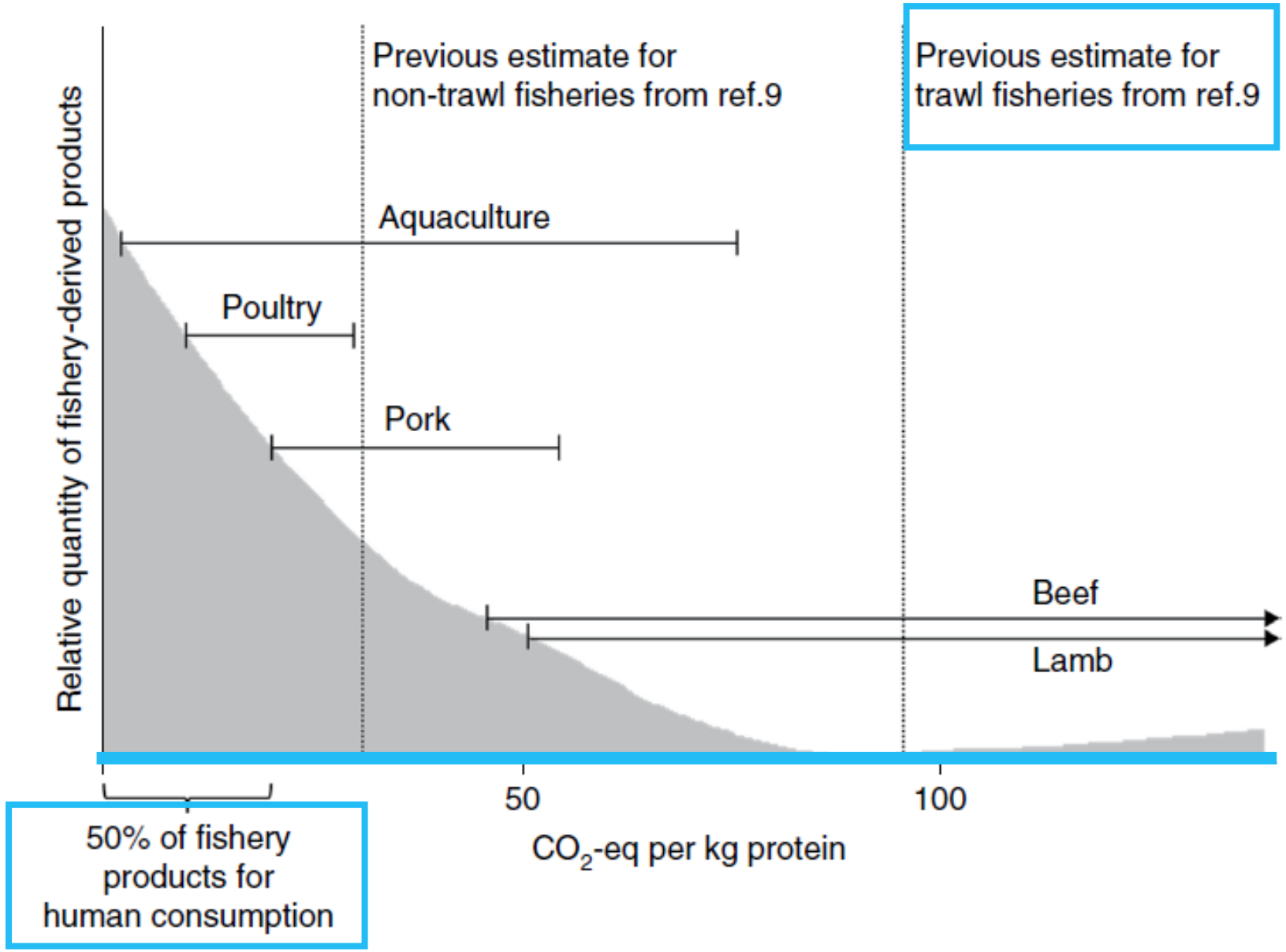
Sepideh Jafarzadeh
Forsker, Sjømatteknologi, SINTEF Ocean
Trondheim, 13.11.2018

World Fisheries



Source: Parker, R.W.R., et al., *Fuel use and greenhouse gas emissions of world fisheries.* Nature Climate Change, 2018. 8(4): p. 333-337.

nature climate change



Source: Parker, R.W.R., et al., *Fuel use and greenhouse gas emissions of world fisheries.* Nature Climate Change, 2018. 8(4): p. 333-337.

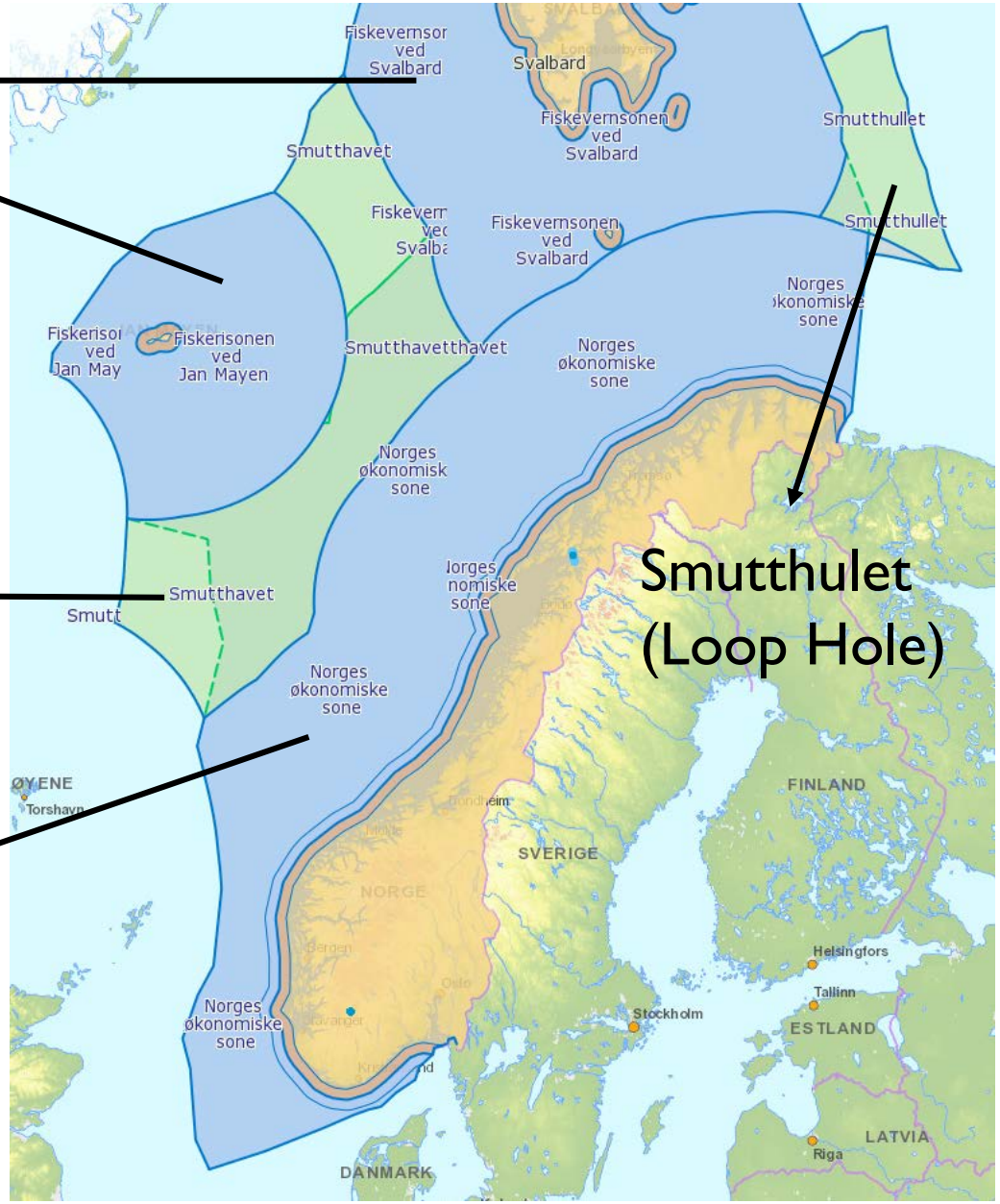
nature climate change

Fishery zones

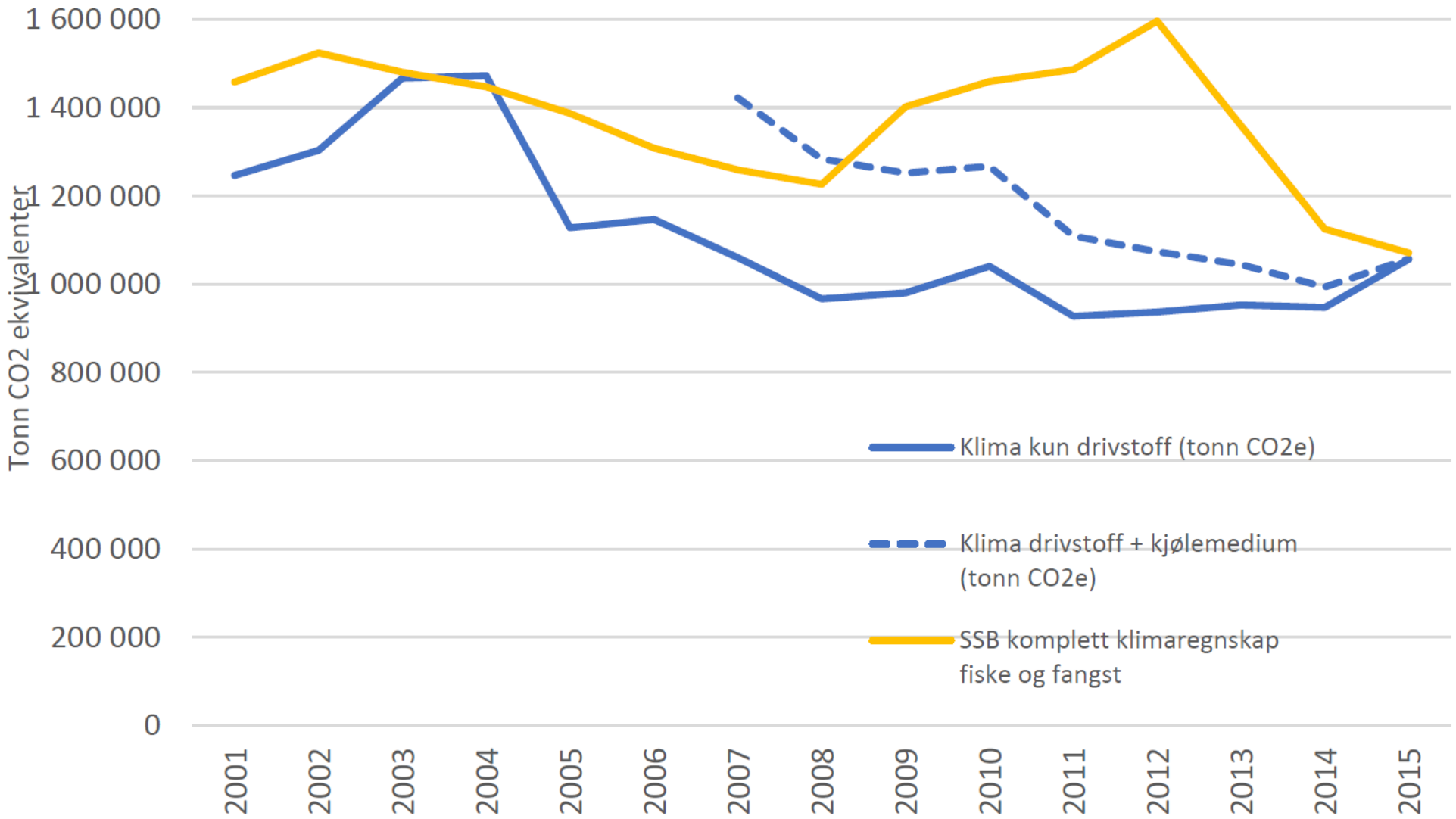
- Fishing vessels: 10.2% (2013)
- Passenger ships (22.3%)
- Offshore supply vessels (15.7%)

Smutthavet
(Banana Hole)

Norwegian
Exclusive
Economic Zone



(*kystverket.no*)



Source: Hognes, E. S., Jensen, J. I. 2017. Drivstofforbruk og klimaregnskap for den norske fiskeflåten, SINTEF Ocean

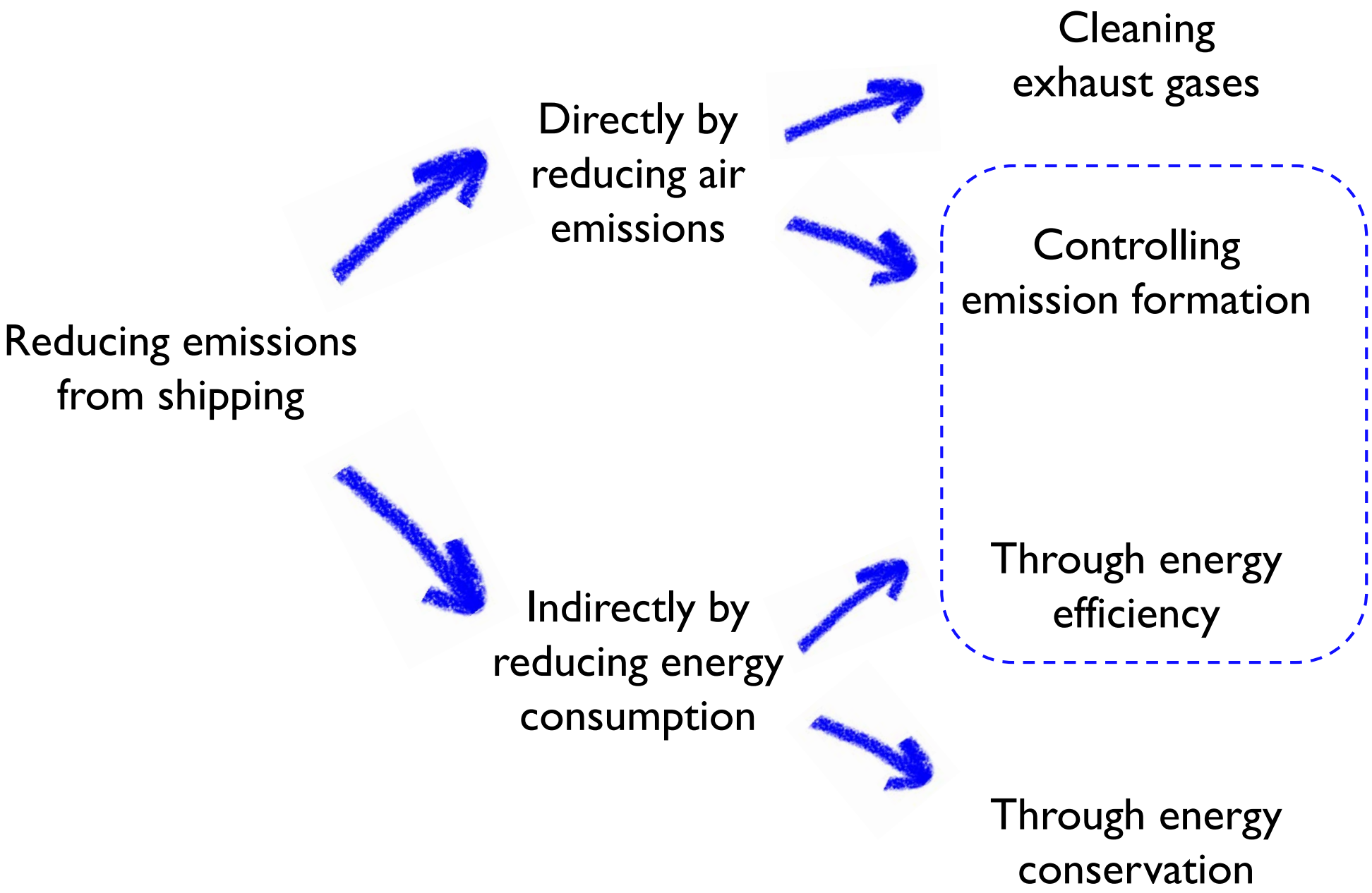
Environmental emissions

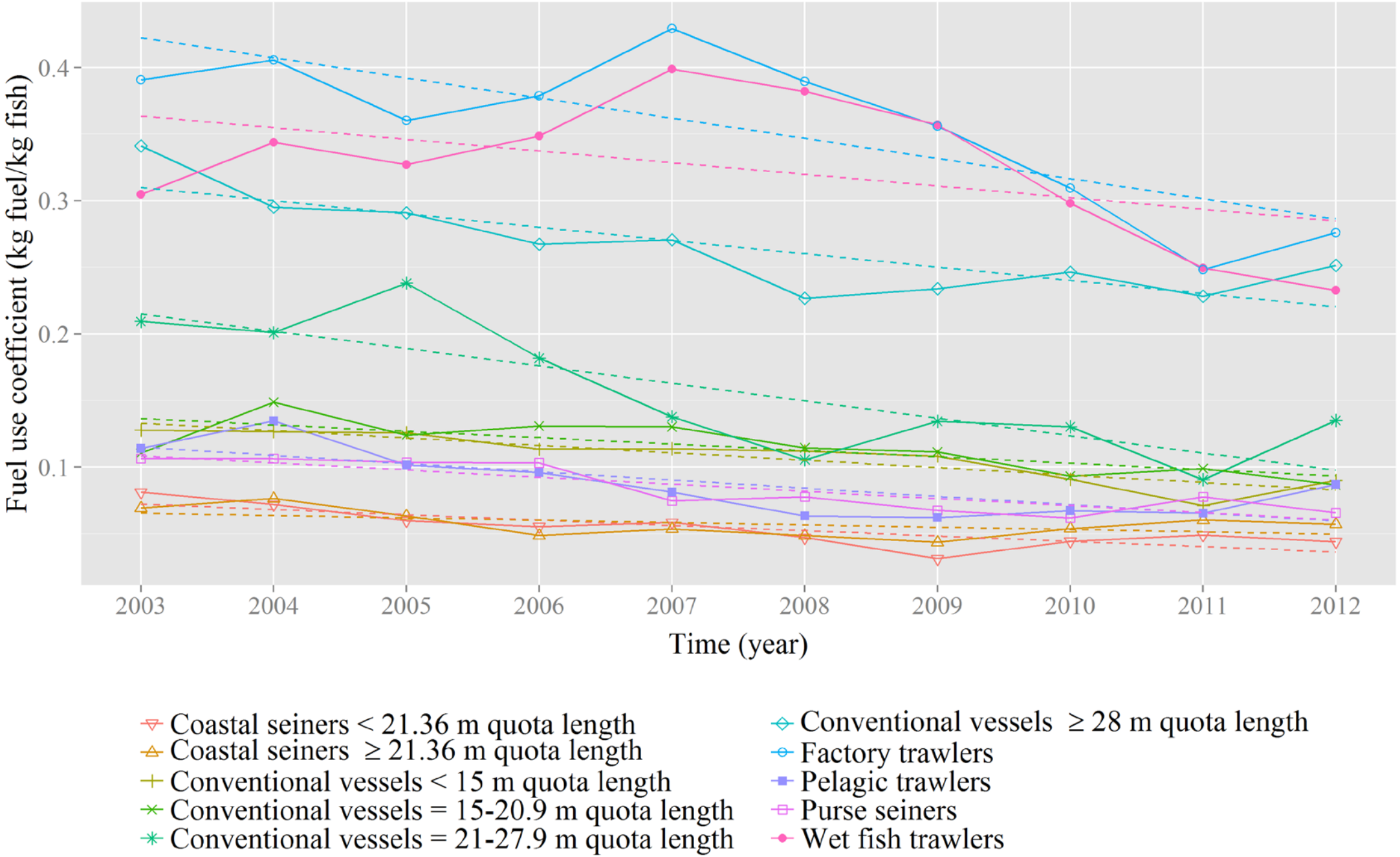
- Environmental and health effects
- MARPOL Annex VI (SOx, NOx)
- Gothenburg protocol (NOx) → NOx tax and fund
- Kyoto protocol (GHG)
- The Paris Agreement (GHG)
- Increased CO2 tax? → CO2 tax and fund?
- Seafood customers' demand



UN's Sustainable Development Goals



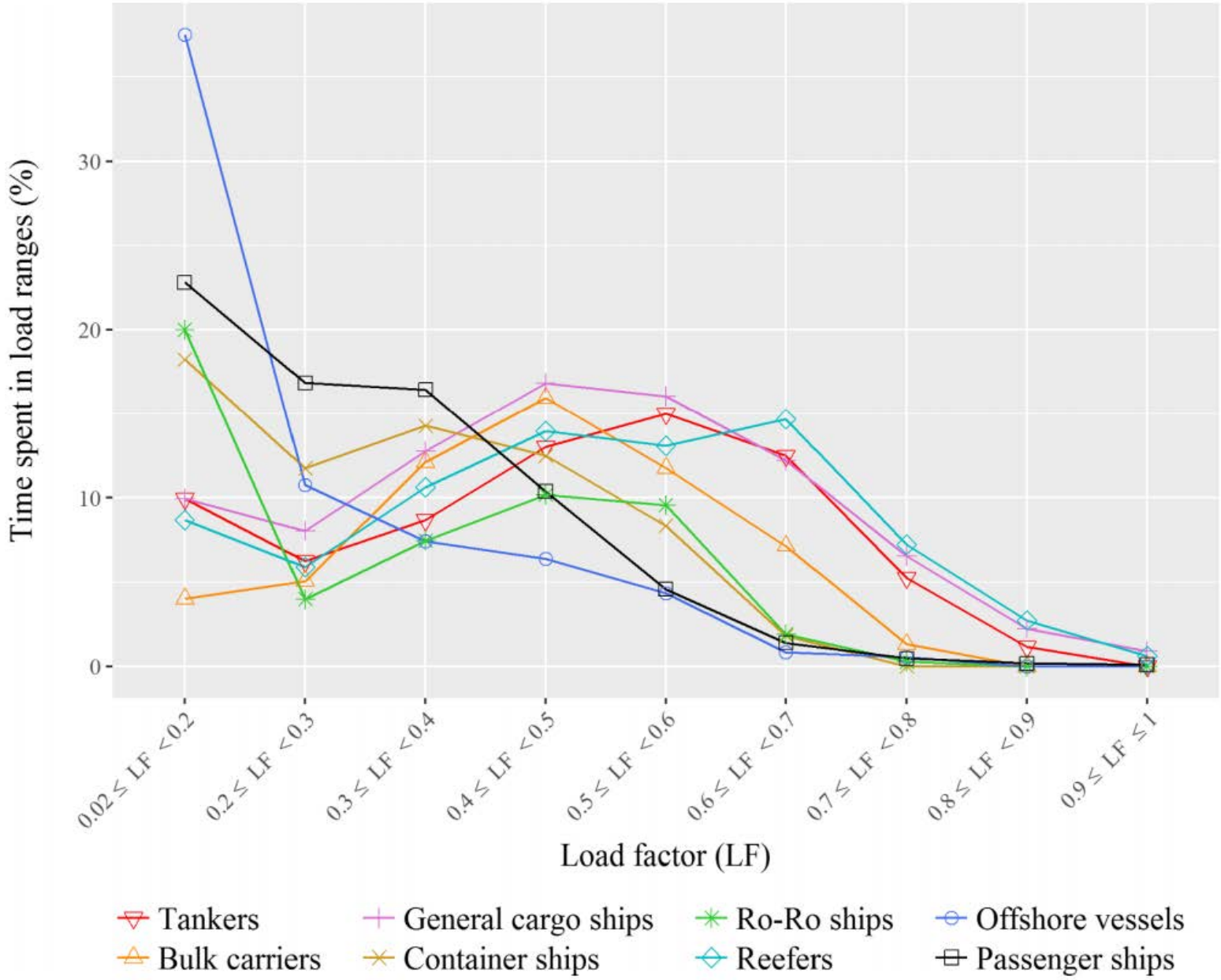

Reducing emissions from shipping
Directly by reducing air emissions
Indirectly by reducing energy consumption
Cleaning exhaust gases
Controlling emission formation
Through energy efficiency
Through energy conservation



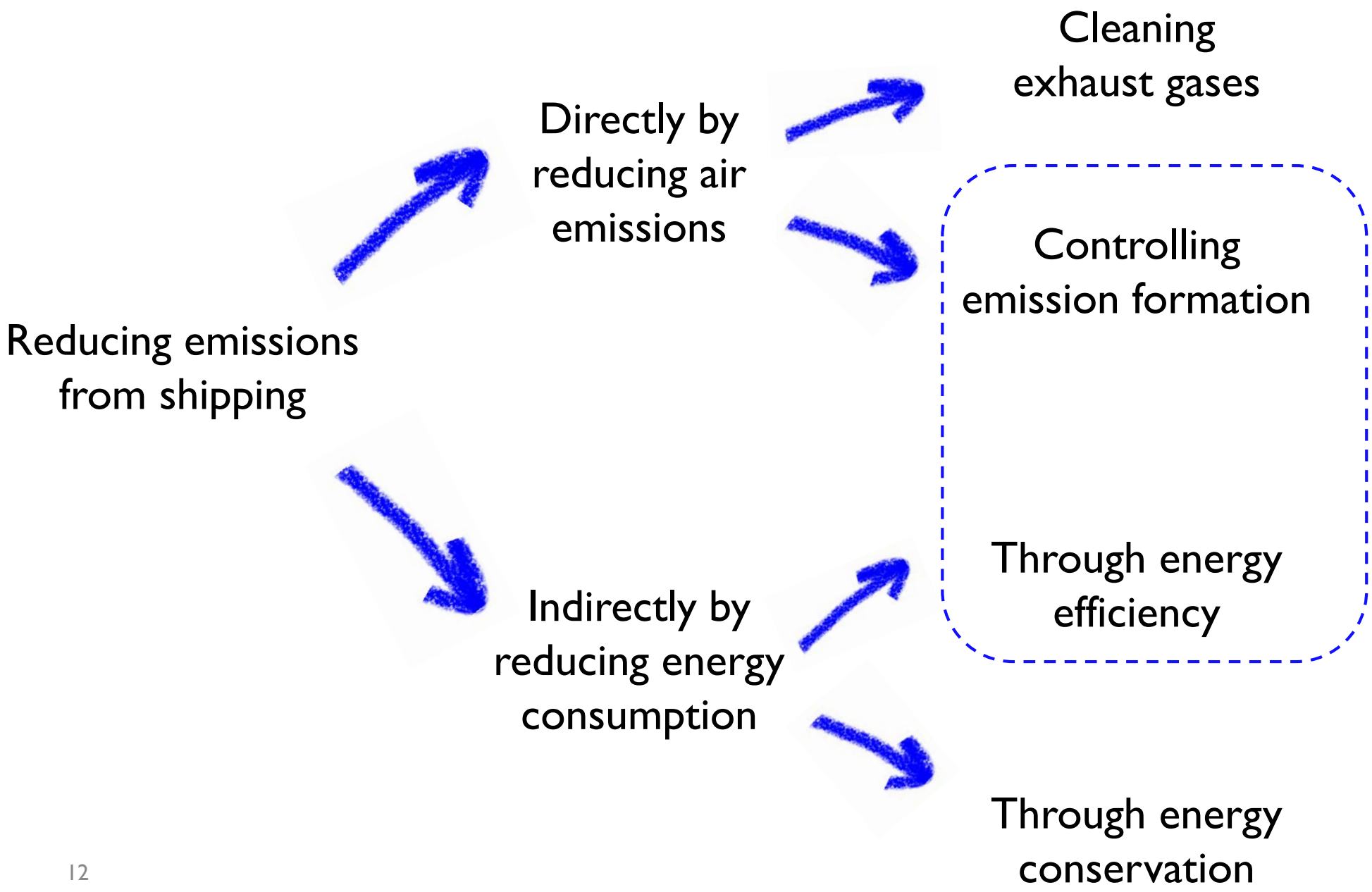
Source: Jafarzadeh, S., H. Ellingsen, and S.A. Aanondsen, *Energy efficiency of Norwegian fisheries from 2003 to 2012.* Journal of Cleaner Production, 2016. 112, Part 5: p. 3616-3630.

Influential factors

- Gear and catch type
- Total stock biomass
- Fish quota
- Fuel price and taxes
- Operators
- Fleet age and technologies
- Single gear versus multiple gears
- Regulations: No focus on energy consumption
- Institutional interactions
- Market demands: All-year-round, focus on energy consumption?
- Propulsion type and size



Source: Jafarzadeh, S. and I. Schjølberg, *Operational profiles of ships in Norwegian waters: An activity-based approach to assess the benefits of hybrid and electric propulsion.* Transportation Research Part D: Transport and Environment, 2018. **65**: p. 500-523.


Reducing emissions from shipping
Directly by reducing air emissions
Indirectly by reducing energy consumption
Cleaning exhaust gases
Controlling emission formation
Through energy efficiency
Through energy conservation

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LNG

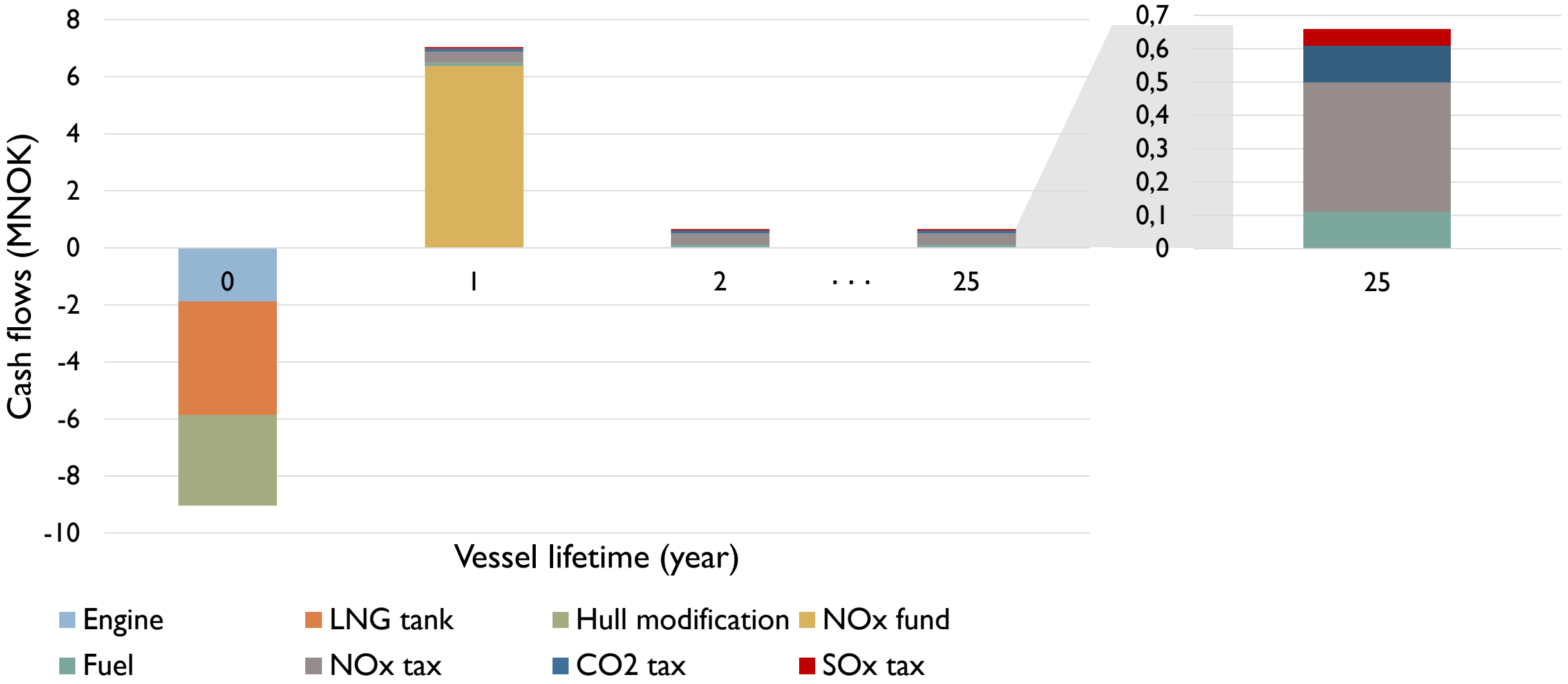
- No SOx and PM
- Up to 90% less NOx compared to HFO
- Approximately 25% less CO2
- Methane slip
  - Otto cycle engines: 2–3%
  - 5.5% leakage in the whole life cycle: No difference in GHG emissions
- Safety aspects
- Economic aspects

Case study

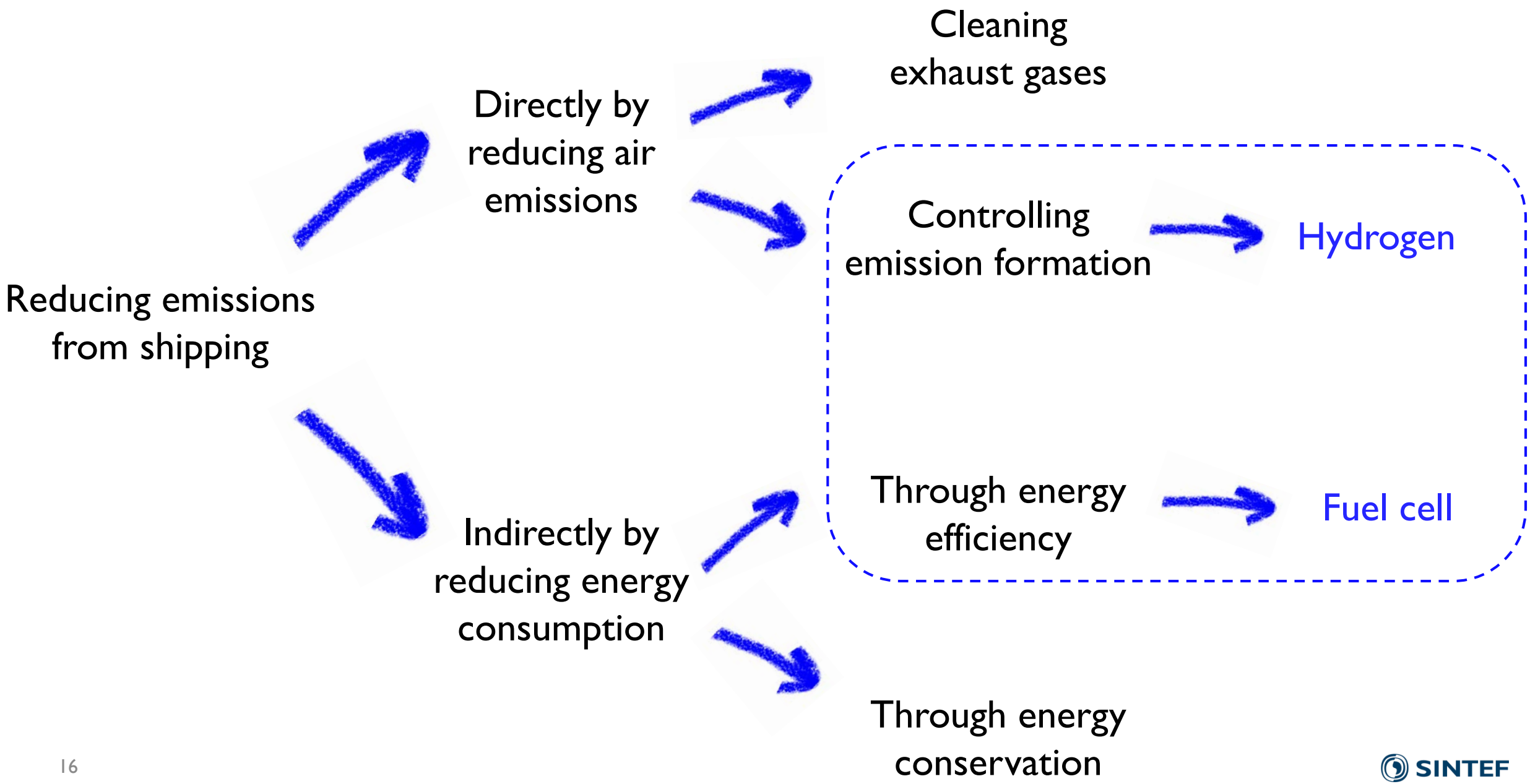
Characteristics of a coastal demersal trawler operating in Norway. The values are derived from Directorate of Fisheries (2014), except for depth, which is assumed.

Characteristic	Value
Length overall (m)	33.18
Breadth (m)	7.20
Depth (m)	5.96
Gross tonnage	279
Main engine power (kW)	760
Days at sea in 2012	280
MGO consumption in 2012 (L)	407,030
Catch in 2012 (kg)	164,454

Source: Jafarzadeh, S., et al., *LNG-fuelled fishing vessels: A systems engineering approach.* Transportation Research Part D: Transport and Environment, 2017. 50: p. 202-222.



Source: Jafarzadeh, S., et al., *LNG-fuelled fishing vessels: A systems engineering approach.* Transportation Research Part D: Transport and Environment, 2017. 50: p. 202-222.

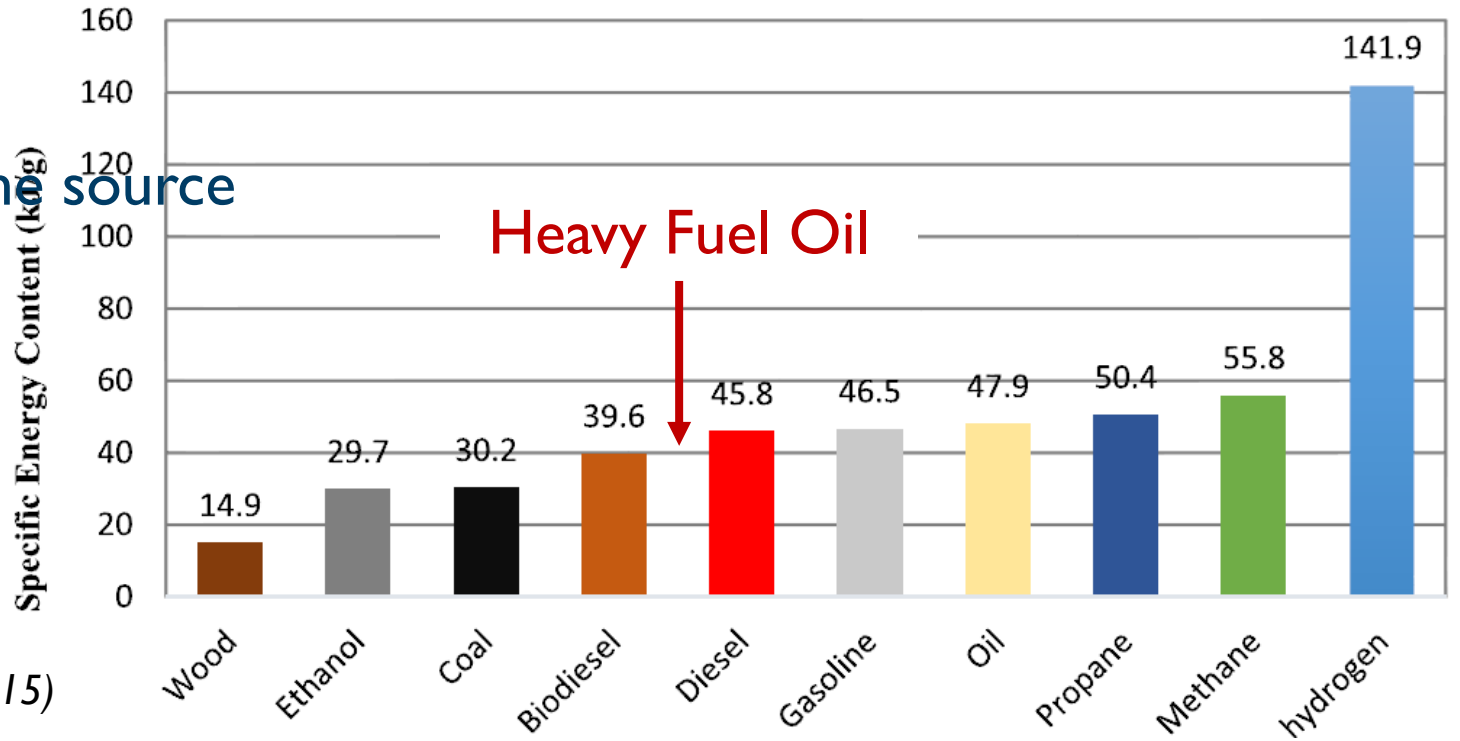

Reducing emissions from shipping
Directly by reducing air emissions
Cleaning exhaust gases
Controlling emission formation
Hydrogen
Indirectly by reducing energy consumption
Through energy efficiency
Fuel cell
Through energy conservation

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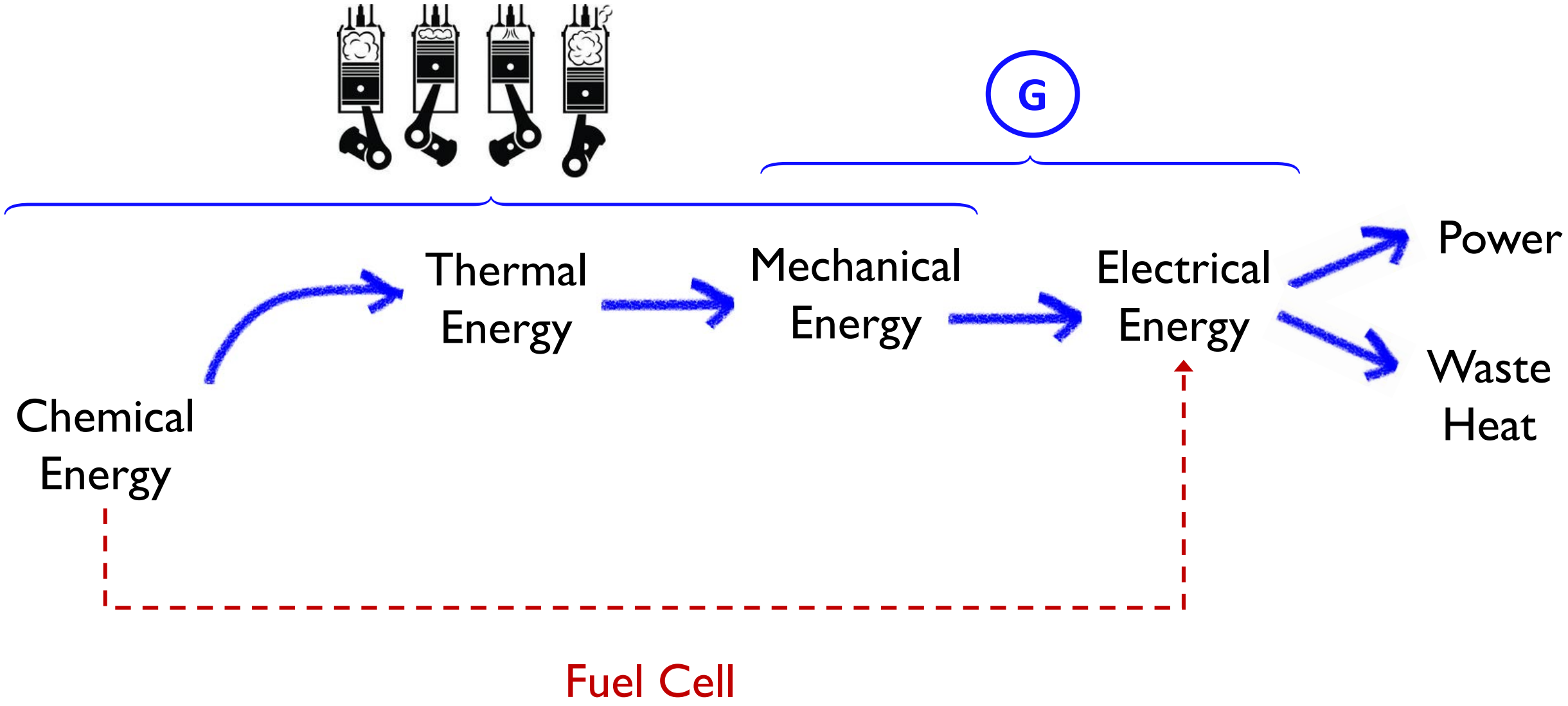
Why hydrogen?

- Trend towards less carbon and more hydrogen in fuels

- Energy content ↑
- Carbon free depending on the source



(Suleman et al., 2015)



Source: Jafarzadeh, S. and I. Schjølberg. *Emission reduction in shipping using hydrogen and fuel cells*. in *ASME 2017 36th International Conference on Ocean, Offshore and Arctic Engineering (OMAE2017)*. 2017. Trondheim, Norway: ASME.

Electrical power



- Auxiliaries
- Propulsion
  - Diesel-electric
  - Hybrid configurations
  - Batteries
- Reduced fuel consumption for ships with variable power demand
- Less propulsion noise and vibration
- Better maneuverability
- Flexible spaces



Source: Siemens

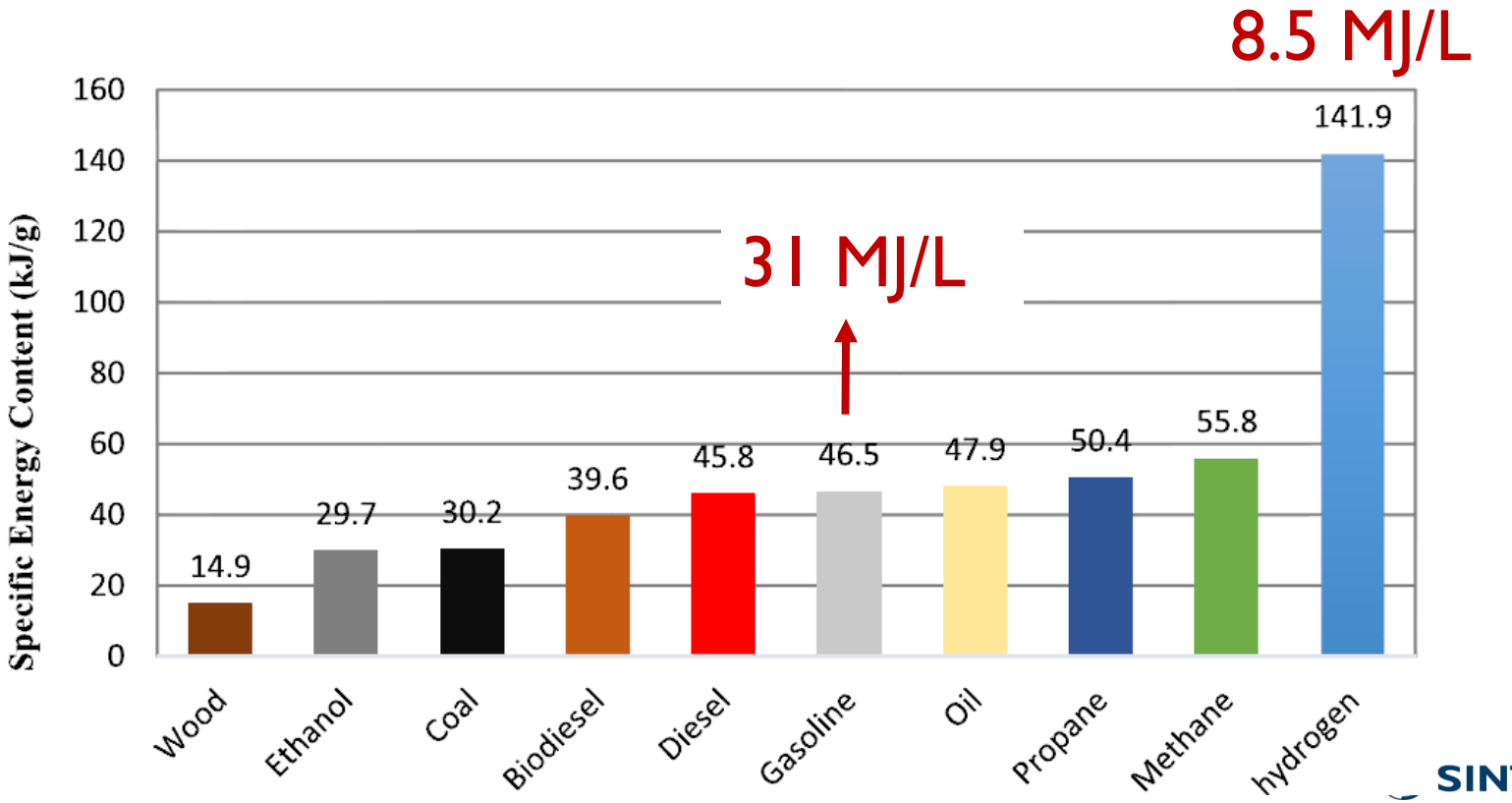
Benefits

- Environmental performance (H2 source)
- More control on where CO2 is produced (carbon capture,…)
- Easier co-generation of electricity and heat (high-temperature FCs)
- Storage of excess electricity from renewable energy surplus
- Improved efficiency (especially part-load)
- Modular and flexible design
- Reduced maintenance
- Alternative to cold-ironing
- Noise and vibration reduction (fishing ships, …)
- Water generation (space)
- Reduced infrared signature (submarines)

Challenges

- Infrastructure
- Cost
- Lifetime and durability
- Size of H2 tanks
- FCs are sensitive: ship
- Significant change in sh
- Safety
- Social acceptance

(Suleman et al., 2015)



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Conclusions

- Energy efficiency and emissions vary among fleet segments.
- Various influential factors: gear, total stock biomass, quota, …
- Alternative fuels: LNG, Hydrogen, …
- Alternative power systems: batteries, diesel-electric, fuel cells…



Technology for a better society