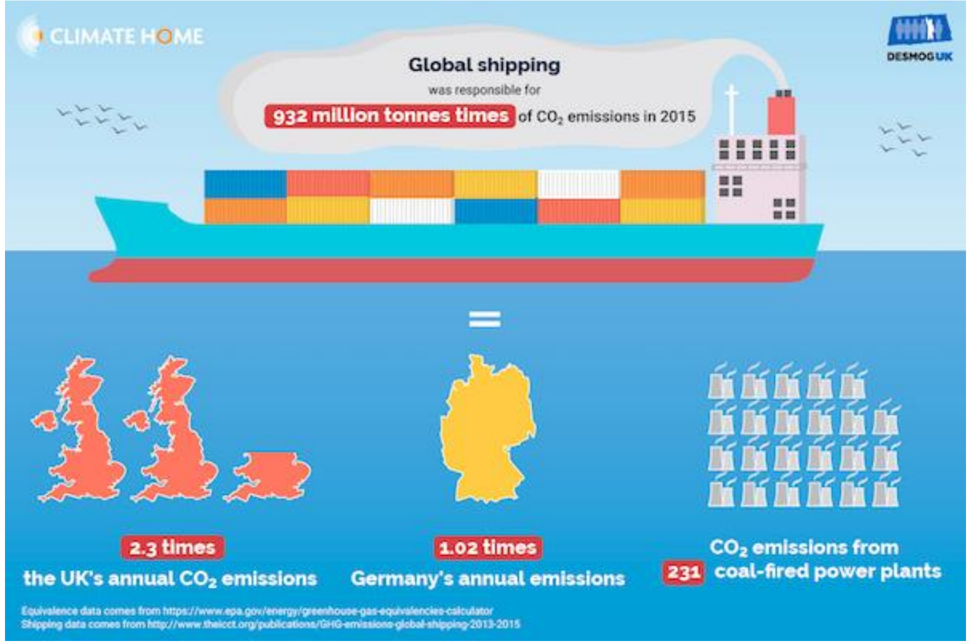
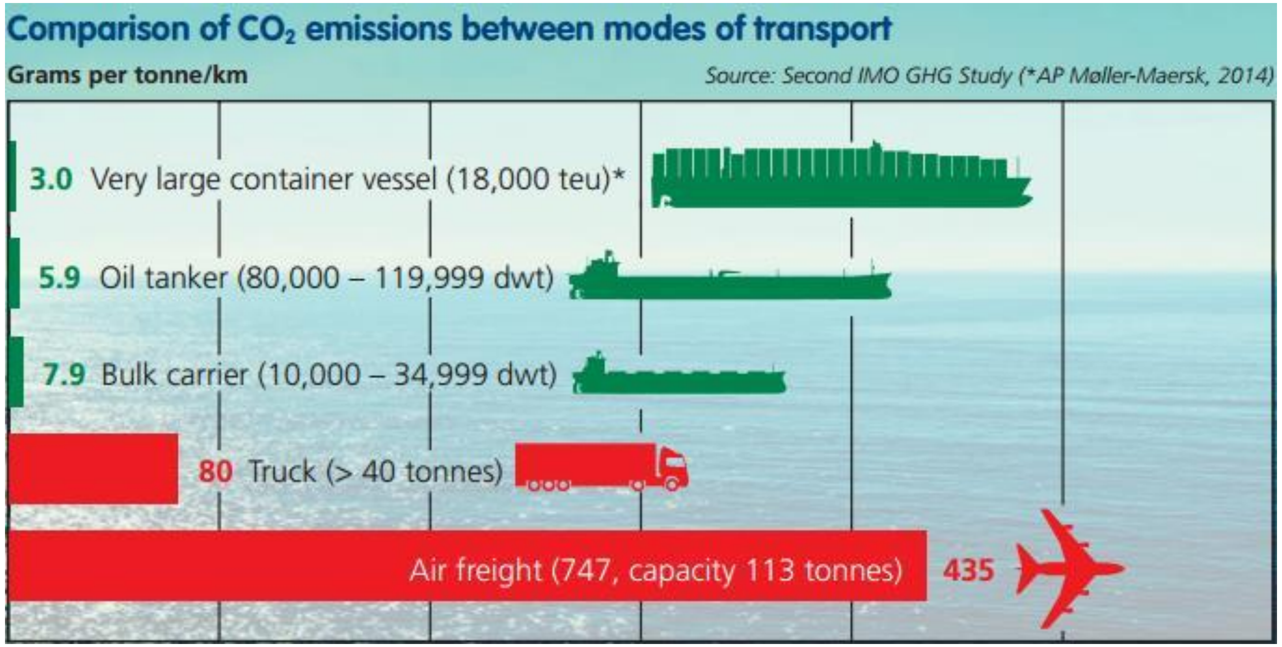

IMPROVING EFFICIENCY WITH WASTE-HEAT

Global Emissions

- CO_2 emissions 2015: **932 MT (IMO 2015)** 2,2% of Global
- Business as Usual scenario: Emissions to increase by 50 % - 250 % by the year 2050 due to global maritime trade
- Ships most fuel efficient mean of transport (fuel-to-cargo ratio) Carries up to 80 % of global trade

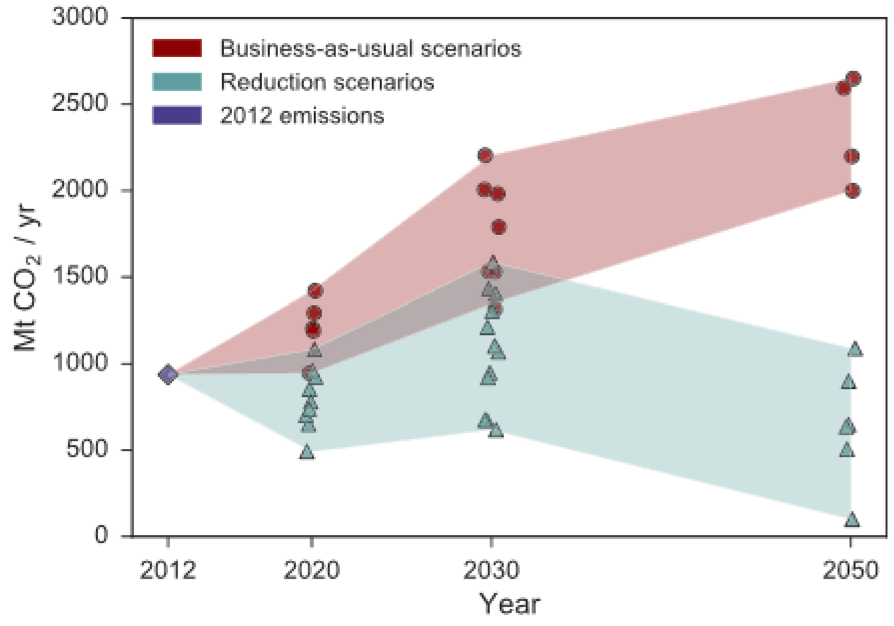




Greenhouse Gas Emission reduction regulations

As a result, GHG-reduction regulations targeting marine traffic are being put into place around the world:

- **The International Maritime Organization (IMO)** has adopted mandatory measures to reduce GHG emissions and completely phase them out by the end of this century. Their initial strategy will reduce total GHG emissions from international shipping by at least 50% of 2008 levels by 2050.
- **The European Maritime Safety Organization (EMSA)** plans to cut the EU's carbon dioxide emissions from maritime transport by at least 40% (from 2005 levels) by 2050. Additional ECAs are being discussed for the Arctic, Central America, the Mediterranean and Black Seas, Japan, the Koreas, and Australia.
- Other national regulations

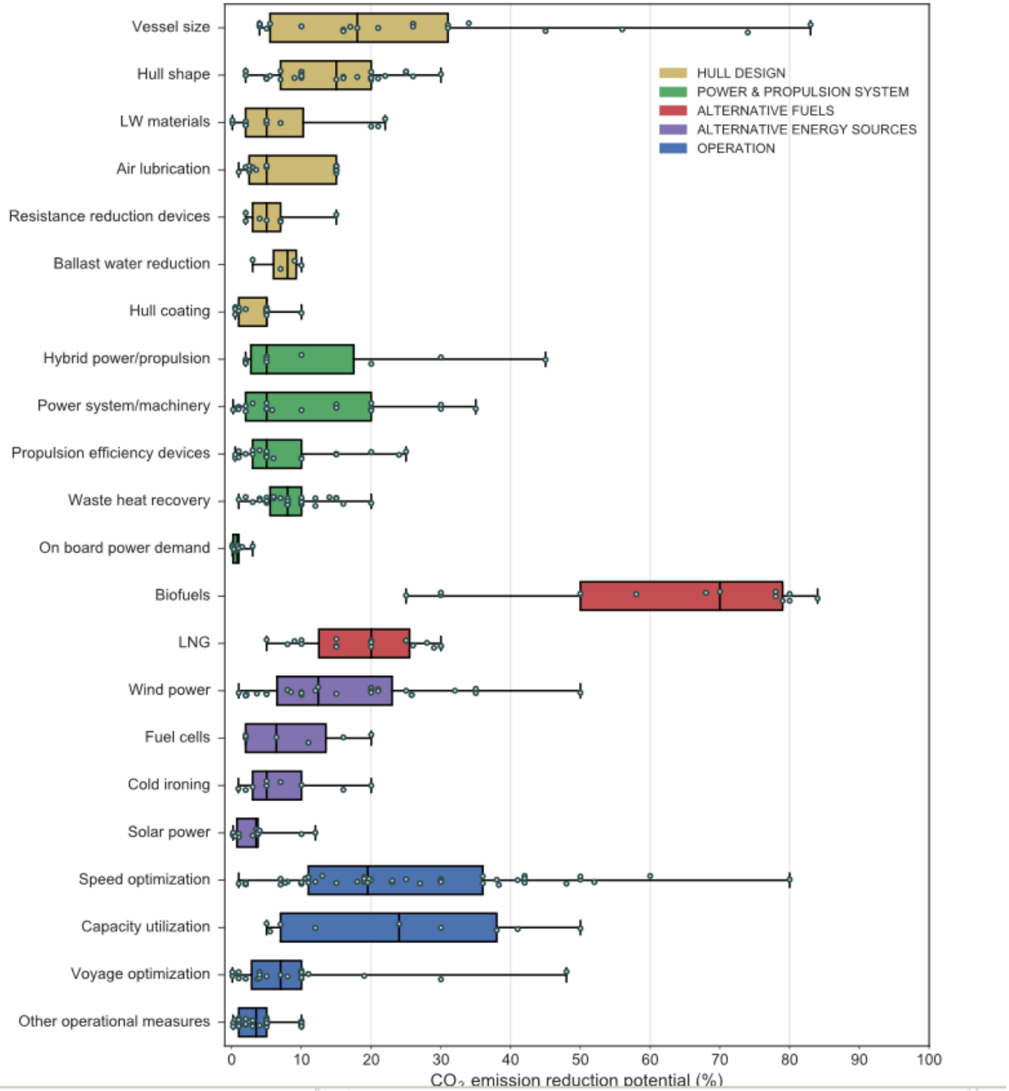


CO_2 emission reduction potential

Potential: A reduction of 75 % with current technologies, (Bouman et Al 2017)

- Looking at the emission reduction potential Vessel size, biofuels and speed optimization have the most significant reduction potential

- Due to vessel size optmiziation and speed control, emissions have reduced.



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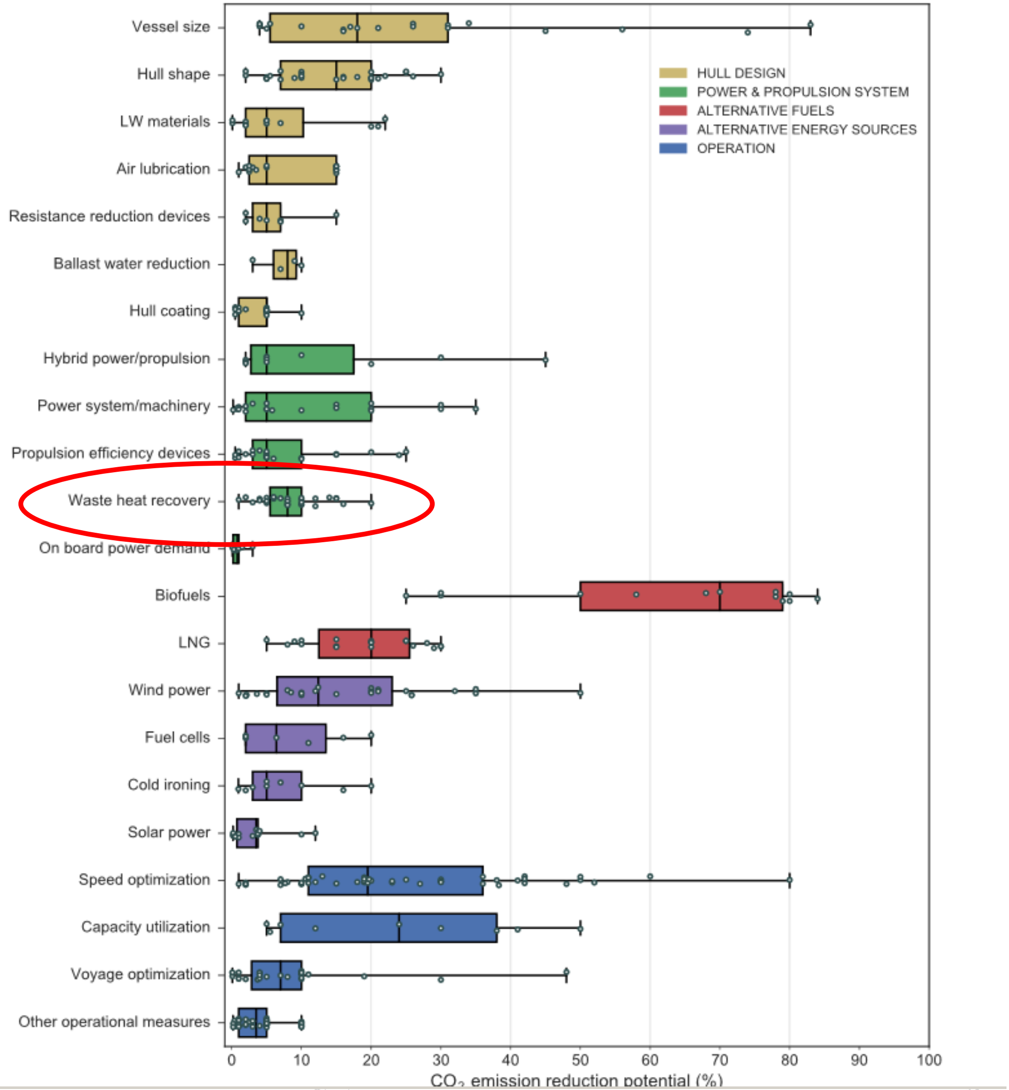
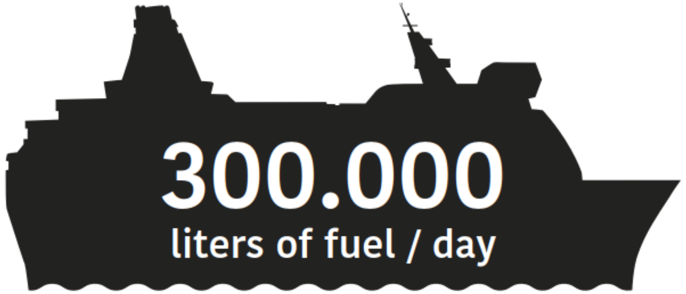
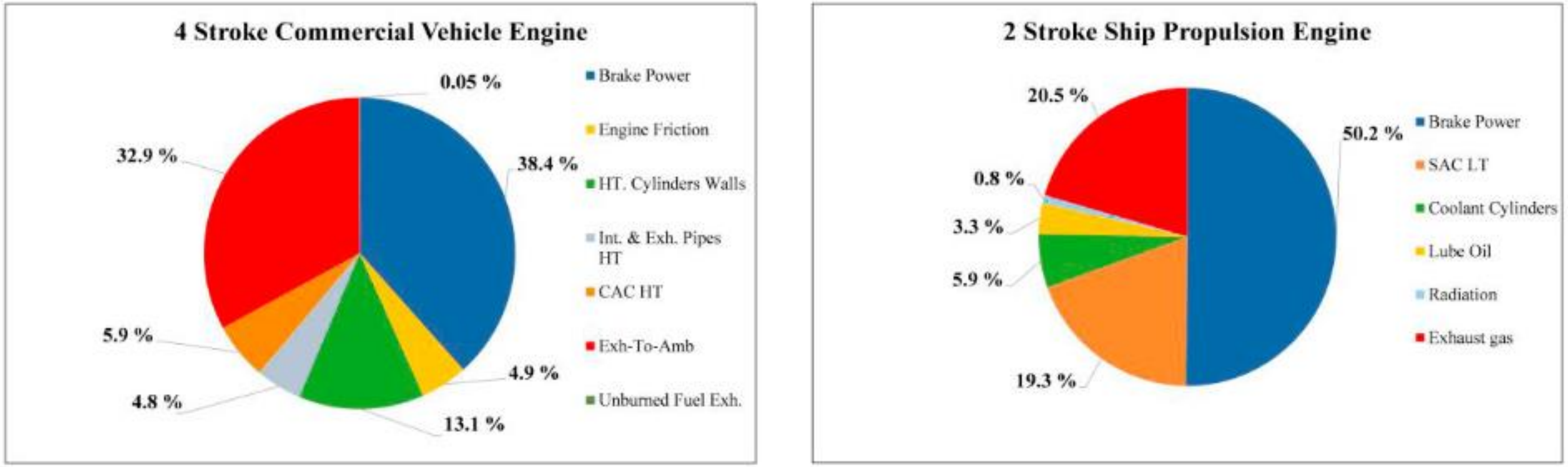


Why Waste Heat Recovery





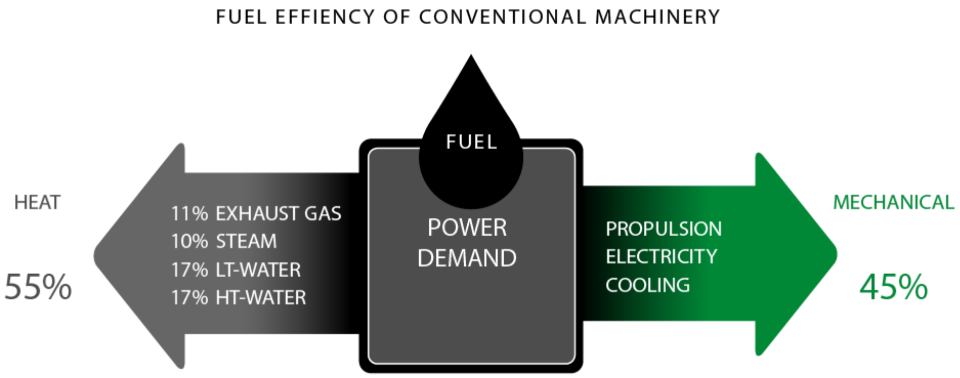
(a) (b)

Fig. 1. Heat balances examples: (a) 200 kW commercial vehicle engine heat balance, (b) 13.6 MW ship propulsion engine

Why Waste Heat Recovery

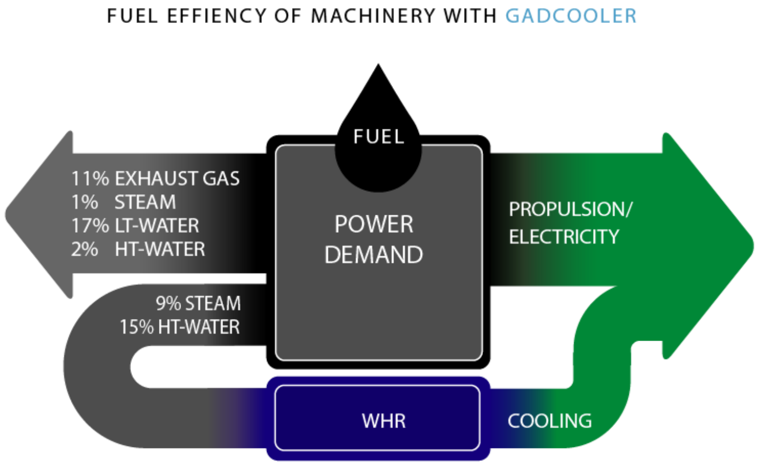
<u>Without waste heat recovery:</u>

- Over half of fuel energy lost



<u>With waste heat recovery:</u>

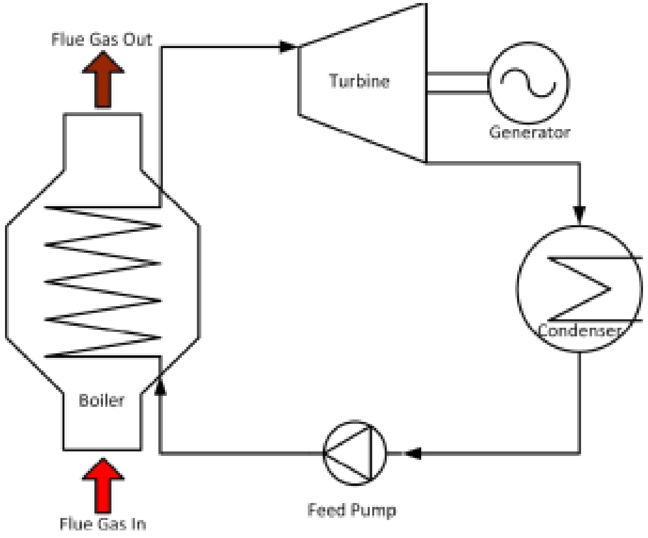
- More Fuel energy is put to good use



Waste heat recovery technology

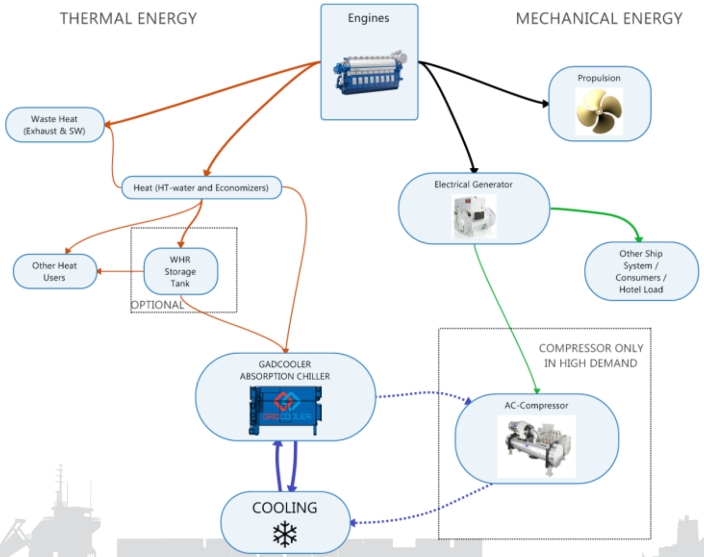
ORC: Electricity out of Waste Heat

- ORC, potential
- Needs high temperatures (Ships normally have excess of 90 deg + steam)
- Electricity
- Reduction potential of 2 - 6 %



Absorption: Air Conditioning out of Waste Heat

- Cooling
- Only when cooling needed
- However most ships have cooling needs
- 80 – 85 % efficiency
- Reduction potential of 2 - 9 %



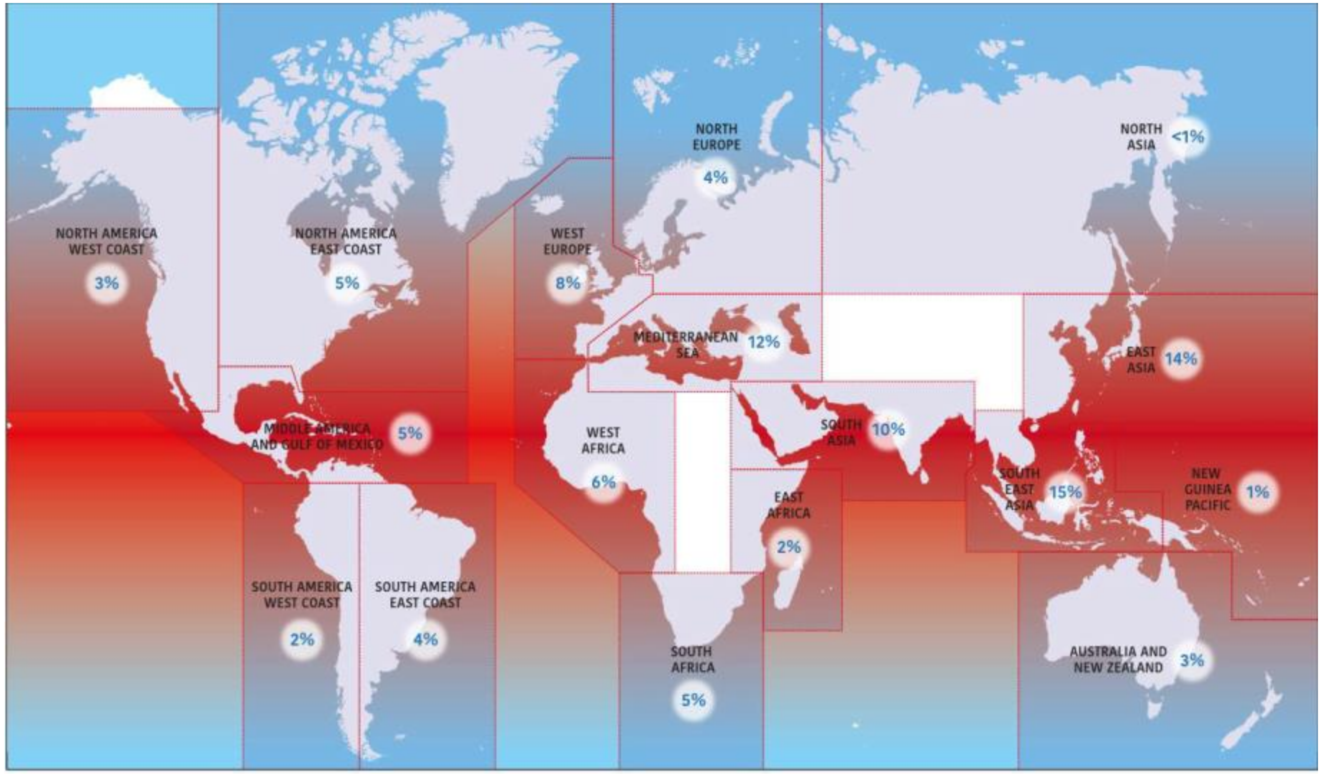
Current ships operating 50 000 (Mid and Large size)

Absorption chiller 3 year pay back time (retrofit installation)

Most ships need cooling (Over 60 % in warm climates)

Large scale for Cruise Lines

Small scale for Container & Tankers



Ships Sightings: total distinct number of ships sighted by geographical area. Source: ASXMarine, Vesseltracker, Marinetraffic Shippax Databases

Reference: Pilot installation onboard Eckerö Line m /s Finlandia

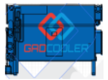
Eckerö Line m/s Finlandia

- Tonnage 36,093 GT
- Length 175 m
- Beam 27,6 m
- Installed Power 4 x Wärtsilä 12V46
- Speed 27 knots
- Capacity 2,080 passengers

m/s Finlandia Savings (500 kW Gadcooler) installed 2016

- Cooling Period
  Baltic – Gulf of Finland) $3\frac{1}{2}$ months / y
  ear
- Cooling Demand
  300 – 1000 kW_C
- Fuel Savings During Cooling Period 70 ton
- Electrical Enegy Saved during Cooling Period 340 MWh_E

EXAMPLE of ABS WHR SAVINGS

Comparison				
Cooling Technology			AC-Compressor only	 Gadcooler Absorption Chiller
Cooling Needed per year	$t_{Cooling\ period}$	months/year	12	
Cooling Capacity		kW_c	3 000	3 000
Electricity Used (COP of AC compressor = 5)	E_{USED}	kW_E	600	5
RUN-time of Chiller	n		100 %	66 %
Savings				
Fuel burned on Cooling (0,217 kg/kWh*)	$FUEL_{USE}$	kg/h	117,07	0,98
Electricity Used for the year		MW_E	5256	1787
Fuel spent in one year. Considering the run time of the Gadcooler Chiller Unit. 34 % of the remaining cooling demand time, when the ship is in port and there is not enough waste heat to power the system, Cooling need to be done by the AC-Compressor, which is installed beside the absorption system	$FUEL_{USE}$	ton/year	*1026*	354
FUEL SAVED WITH GADCOOLER CHILLER per YEAR	FUEL	ton/year	*671*	

kWh_E – Electrical kWh
kWh_C – Cooling/Heat kWh

Globally

Using only waste heat to power Air Conditioning we can

Reduce Global CO_2 emission by **10 Mt / year**