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EU Transport GHG: Routes to 2050?

Technical options for maritime and inland shipping

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Stakeholder meetings

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www.eutransportghg2050.eu

Partners

AEA CE Delft TNO ISIS milieu

Overview of presentation

1. Introduction to the presentation

2. Technical options for maritime and inland waterways

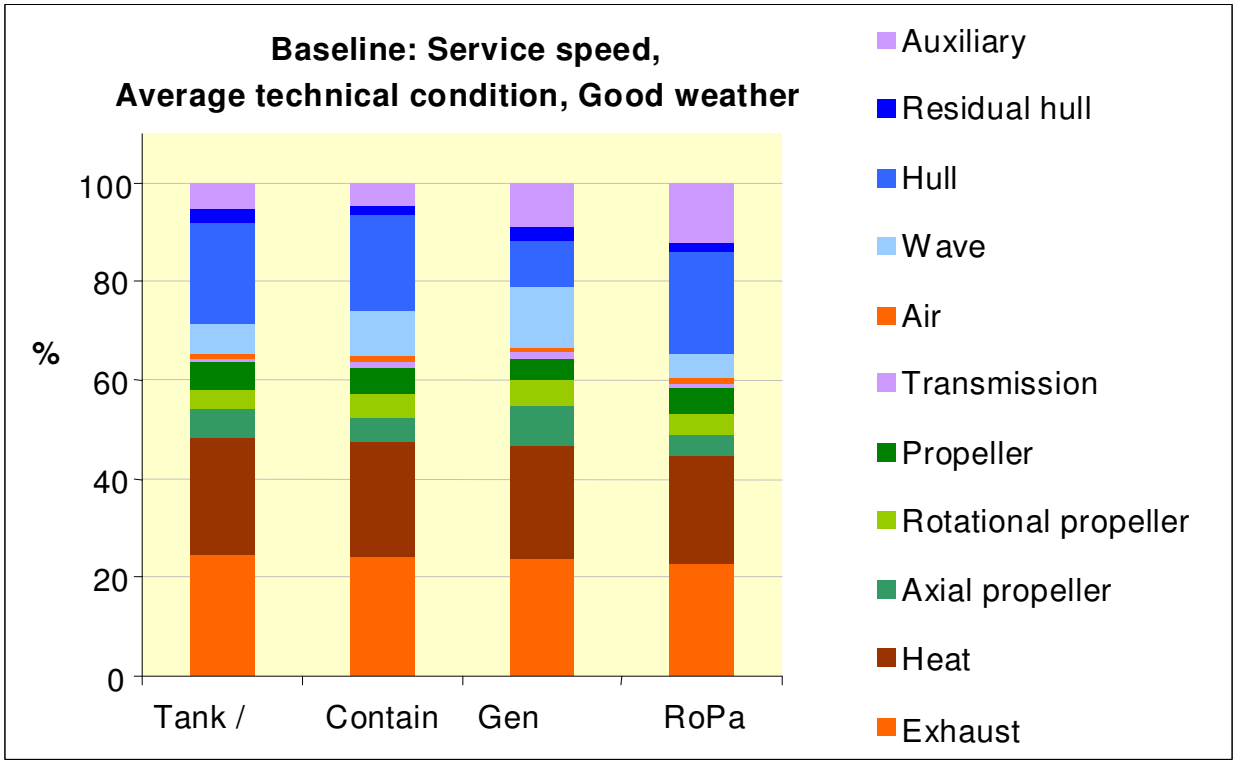
3. Alternative fuels/energy carriers for maritime and inland waterways

4. Conclusions/discussion/questions

Introduction to the Presentation

- Based on:
  - Paper 2 – Alternative Energy carriers and Powertrains to reduce GHG emissions from transport (Nik Hill, et al, incl Tom Hazeldine)
  - Paper 3 - Technical options to reduce GHG emissions for non-road transport modes (Tom Hazeldine et al, inc. Huib van Essen)
- Presentation is based on draft findings set out in the papers
- Aim of subsequent discussion is to:
  - Agree what we know and do not know
  - Identify any omissions in our information/sources
  - Review the conclusions that are emerging

Baseline distribution of the energy consumption of selected maritime vessels

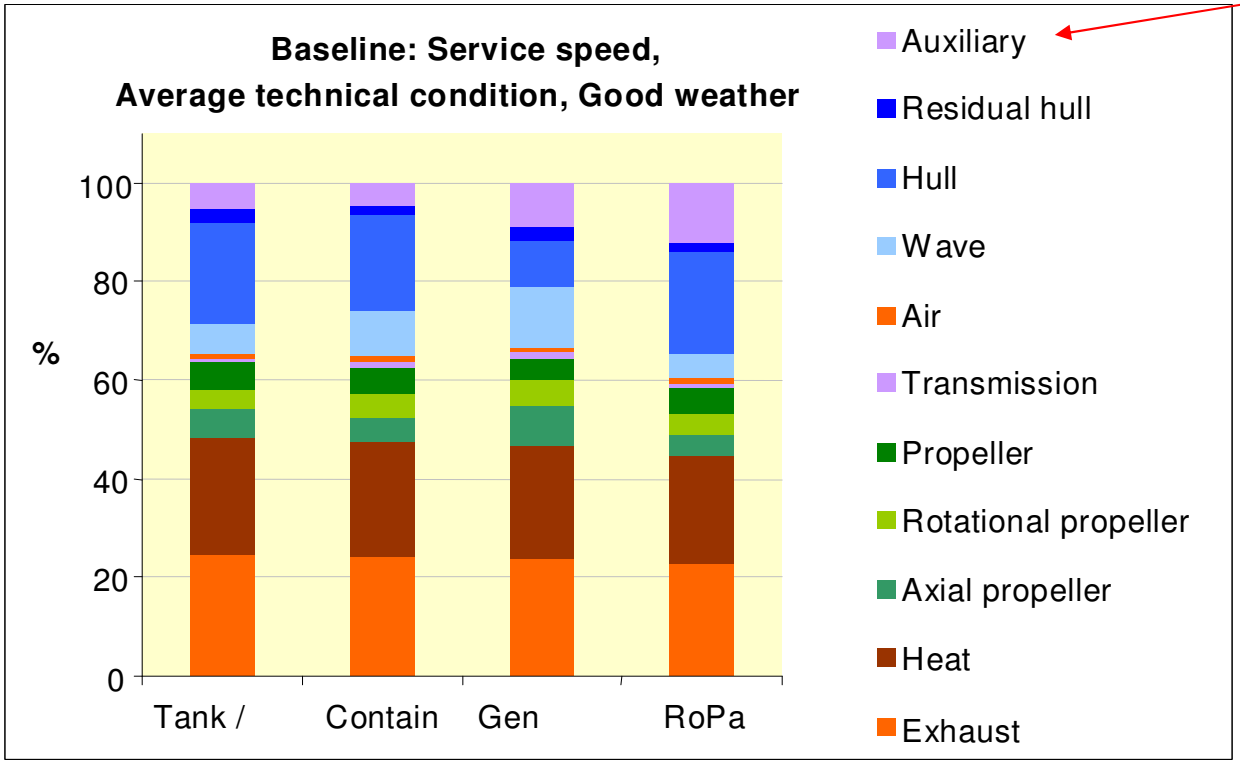


- "Typical" ships in average condition operating at service speed

Source: AEA, Marintek, CE Delft, DLR, Entec, MMU (2008) for UK Committee on Climate Change

Baseline distribution of the energy consumption of selected maritime vessels

Not all for propulsion



- "Typical" ships in average condition operating at service speed

Source: AEA, Marintek, CE Delft, DLR, Entec, MMU (2008) for UK Committee on Climate Change

Technical options for marine and inland waterway vessels: Overview

- Many similar options for inland waterway and marine vessels
- Options with respect to the **hull -** e.g. reducing friction and lighter hulls
- Options with respect to the **propeller -** e.g optimisation, upgrade and energy recovery
- Options with respect to **propulsion/engine -** e.g. Upgrading and energy recovery
- Other options - e.g. Making hulls larger and different sources for auxiliary engines
- Sources:
  - Mainly recent IMO work for maritime
  - Dutch and German studies for inland waterways

Measures with respect to the hull - Marine

Short term (existing vessels), so pre 2020:

- Reducing frictional resistance of hull surface (payback: < 1 year):
  - "Modern" coatings: Max 5% (Wartsila, 2008);
  - Longer-term: Coatings based on nanotechnology: 15%? (IMO, 2009)
  - Potential problems with applying coatings at optimal times

Long term (new vessels), so post 2020:

- Reducing weight of hull (payback: < 1 year):
  - Max 7% saving (Wartsila, 2008)
  - Barriers include safety requirements and patents (IMO, 2009)
- Optimise flow wrt transverse thruster openings/adding grids (payback: < 1 year):
  - 1 to 5% saving (Wartsila, 2008)
- Optimisation of hull design (pay back: > 15 years):
  - 5% to 20% reduction per ship (still water; IMO, 2009); 9% (Wartsila, 2008)
- Air lubrication (pay back: > 15 years):
  - Air cavity system: > 5%; 10 to 15% for tankers?
  - Total max: 1% to 2% (by 2020); more after?

Measures with respect to the hull – Inland waterways

Short term (existing vessels), so pre 2020:

- Improved hull designs (short payback time):
  - Potential improvements of around 5% on existing ships (Wartsila, 2009)

Long term (new vessels), so post 2020:

- Improved hull designs (short payback time):
  - Potential improvements of between 5% to 20% possible on new ships (Wartsila, 2009)
  - "Duck tail" (which effectively lengthens the vessel): Reduce demand for propulsion power by 4 to 10%

- Lightweight hulls (payback: > 10 years):
  - Extensive use of composite materials (Experimental "CompocaNord" study): Potential energy savings of 15% fleet-wide?? Increase in hull costs of 30%??
  - Aluminium/light weight steel: 5% fuel efficiency improvement (Wartsila, 2009); cos

- Air lubrication (payback: unknown?):
  - Needs production of compressed air: Potential energy savings: 17% (de Grave and van Wirdum, 2006); potential application not known

Measures with respect to the propeller - Marine

Short term (existing vessels), so pre 2020:

- Recovery of propeller energy (IMO, 2009) (payback: < 10 years?):
  - Contra rotating propeller: reduction level per ship: 3 to 6%
  - Grim vane wheel: 10% per ship
  - Ducted propeller: Average 10%
  - Post-swirl devices: 8 to 9% (additional thruster/fins on rudder); 4% (boss cap fins) - costs: $20,000 to $150,000 per engine (depending on power)

- Propeller upgrades:
  - Larger diameter propeller: 5-10% improvement (IMO, 2009); max: 4% (Wartsila, 2008); ***payback 1 to 15 years***
  - Special tip shapes (winglets): Max: 4%; ***payback <1 year*** (Wartsila, 2008)

- Optimisation of propellers (payback: > 15 years?):
  - E.g. large blade, slow rotation speeds, minimise number of blades (IMO, 2009)
  - Reduction potential and costs not known

Measures with respect to the propeller – Inland waterways

Short term (existing vessels), so pre 2020:

- Optimisation of conventional propellers (short payback):
  - Flattened, ducted propellers (propeller tubes)
  - Increase in fuel efficiency per vessel 20% to 30% (de Grave and van Wirdum, 2006; Lensink and de Wilde, 2007)
  - Total potential reduction not estimated; cost: €50,000 per vessel

Long term (new vessels), so post 2020:

- New propeller designs (unknown payback):
  - "Whale tail wheel" has claimed potential savings of up to 50%...
  - … although technology not yet proven (RIVM, 2002)

Measures with respect to propulsion/engine - Marine (1)

Short term (existing vessels), so pre 2020:

- Engine upgrade (Wartsila, 2008; IMO, 2009):
  - Common rail technology: Max 1% saving per ship; **payback: < 15 years**
  - Engine tuning: Max 1% saving per ship **(unknown payback)**
  - Barriers: Significant engineering work required; best applied to older ships?

Long term (new vessels), so post 2020:

- Recovery of engine energy (from waste heat) (payback: < 15 years):
  - Would require extensive modification of existing vessels
  - 10% potential saving per ship
  - Barrier: size, weight and complexity of thermo efficiency systems (IMO, 2009)
  - Potential future: Organic Rankine Cycle systems? (IMO, 2009)

Measures with respect to propulsion/engine - Marine (2)

Long term (new vessels), so post 2020:

- Flettner rotors (payback unknown):
  - Bulk carrier: Three rotors could save 12 to 14% (The Naval Architect, 2008)
  - Max saving on ship level of 30% (Wartsila, 2008)
  - Would potentially inhibit operation of container vessels

- Rotor spins in a moving airstream generating a perpendicular force
- Picture is a catamaran being developed by the University of Flensburg *Uni-cat Flensburg*

Measures with respect to propulsion/engine – Inland waterways

Short term (existing vessels), so pre 2020:

- More efficient diesel engines (payback: > 10 years):
  - Potential saving of between 15 to 20%; cost: €100,000 to €300,000 (RIVM, 2002)
  - 50% of engines in European barges are > 20 years old, so significant potential
  - Co-benefits in terms of reduced air pollutants

Long term (new vessels), so post 2020:

- Diesel electric propulsion (payback: > 10 years):
  - Switching several smaller diesel units on/off to use engines in optimal power range; potential vessel savings: 5 to 10%
  - A few such ships in use (Airbus freight ships); potential not widely assessed
  - Probably not suitable for retrofit, as hull needs modification

Other measures

Marine vessels:

Short term (existing vessels), so pre 2020:

- Efficient lighting (payback: <15 years):
  - Relevant for ferries and cruise vessels where high demand for auxiliary power
  - 0.1 to 0.8% saving per ship, total of 0.6% (Wartsila)
- Controlling speed of pumps and fans (payback: <15 years):
  - 0.2 to 1% saving per ship; widely applicable (Wartsila)

Long term (new vessels), so post 2020:

- Optimisation of superstructure:
  - Large ships operating at high speeds – reduction potential of 2 to 5%

Inland waterway vessels:

- Larger barge units are more efficient in larger waterways (no general conclusion on payback possible):
  - Dependent on large enough infrastructure being available
  - 10% increase in size leads to 4 to 5% saving in energy efficiency (Wartsila, 2009); relationship not linear, though

Alternative energy carrier, fuels and means of propulsion – Marine: Biofuels

Short term (existing vessels), so pre 2020:

- CO_2 impacts dependent on how biofuels produced, transported and use of waste
- Issue of competition with road transport and lower cost of marine fuel
- Research:
  - Concentrated on vessels that use diesel (not fuel oil)
  - Undertaken to produce biodiesel for marine applications that will not compete with road transport (e.g. Biox process that produces pure plant oil)
  - Trials on ships have been undertaken
- Barriers:
  - Main barrier is economic, e.g. price compared to marine fuel
  - Technical barriers include: For a given power output, fuel consumption would be higher, thus requiring larger tanks or smaller ranges.
- While increased lubricity reduces wear and tear, biodiesel may be more corrosive
- Supply might be a problem if large volumes required

Alternative energy carrier, fuels and means of propulsion – Marine: other (1)

Long term (new vessels), so post 2020:

- LNG potential future fuel for ships (payback dependent on fuel prices):
  - 15% reduction potential (taking into account extra methane) (Einang and Per Mange, 2007)
  - Reduction in other emissions as well
  - Barriers: Requires three times the space on ships of equivalent (by energy content) diesel
  - Availability of LPG in ports a challenge that would need to be solved
  - More relevant for new ships, as significant modification required for existing ships
- LPG is not considered a viable option for shipping
- Electric storage for ship powertrains not seen as viable option
- Hydrogen fuel cells (very long payback):
  - Not considered to be viable before 2050 (AEA et al, 2008)
  - Research being undertaken, e.g. Oceanjet concept (Southampton University)
  - Hydrogen-equipped whale watching boat (to provide lighting) in Iceland
  - Zemships project developing a 100 passenger capacity fuel cell ship
  - Barriers: High current costs, reliability, weight/volume, safety of onboard storage and handling of fuels

Alternative energy carrier, fuels and means of propulsion – Marine: other (2)

Long term (new vessels), so post 2020:

- Sails for propulsion (unknown payback):
  - 5 to 7/8% for tankers/bulk carriers at 15 knots (Tech Uni Berlin, 2008); more at lower speeds
- Towing kites for propulsion (long payback):
  - Producer estimates: 10 to 35%; works best on ships travelling < 16 knots
  - Costs: $0.5 million to $3.5 million; installation costs – extra 5-10%; operational – extra 5 to 15%
  - Barriers: Complexity of necessary launch, recovery and control systems
- Solar (to cover auxiliary power) (long payback):
  - 3.5% for tankers (Wartsila, 2008), varies by ship type
  - Efficiencies of solar cells expected to double
  - Could be used in conjunction with sails, etc
  - Back-up power is needed; not an option on all types of vessel; currently expensive

Alternative energy carrier, fuels and means of propulsion – Inland waterways

Long term (new vessels), so post 2020:

- LNG and CNG (payback dependent on fuel prices):
  - LNG: 25% reduction potential (de Grave and van Wirdum, 2006)?
  - CNG being trialled on a ferry in Norway: 20% CO2 reduction achieved (Skjolsvik, 2005)
  - Generally still under development for inland waterway use
- Biofuels and fuels cells:
  - No particular information on potential application in inland waterways
- Solar power:
  - As with marine vessels, not realistic for propulsion; potential use for auxiliary power

Conclusions: Marine, short term (existing vessels), so pre 2020

- **Reducing frictional resistance of hull surface (payback: < 1 year)**
  - "Modern" coatings: Max 5% (Wartsila, 2008)
  - Longer-term: Coatings based on nanotechnology: 15%? (IMO, 2009)
- **Recovery of propeller energy (payback: < 10 years?), various, e.g.:**
  - Post-swirl devices: 8 to 9% (additional thruster/fins on rudder); 4% (boss cap fins) - costs: $20,000 to $150,000 per engine (depending on power)
- **Propeller upgrades:**
  - Larger diameter propeller: 5-10% improvement (IMO, 2009); max: 4% (Wartsila, 2008); ***payback 1 to 15 years***
  - Special tip shapes (winglets): Max: 4%; ***payback <1 year*** (Wartsila, 2008)
- **Optimisation of propellers (payback: > 15 years?)**
  - Reduction potential and costs not known
- **Engine upgrade:**
  - Common rail technology: Max 1% saving per ship; **payback: < 15 years**
  - Engine tuning: Max 1% saving per ship **(unknown payback)**
- **Efficient lighting and controlling speed of pumps and fans (payback: <15 years)**
- **Biofuels?**

Conclusions: Marine, long term (new vessels), so post 2020

- **Reducing weight of hull (payback: < 1 year)**
  - Max 7% saving (Wartsila, 2008)
- **Optimise flow wrt transverse thruster openings/adding grids (payback: < 1 year):**
  - 1 to 5% saving (Wartsila, 2008)
- **Optimisation of hull design (pay back: > 15 years):**
  - 5% to 20% reduction per ship (still water; IMO, 2009); 9% (Wartsila, 2008)
- **Air lubrication (pay back: > 15 years):**
  - Air cavity system: > 5%; 10 to 15% for tankers?
  - Total max: 1% to 2% (by 2020); more after?
- **Recovery of engine energy (from waste heat) (payback: < 15 years):**
  - 10% potential saving per ship
- **Flettner rotors (payback unknown):**
  - Bulk carrier: Three rotors could save 12 to 14% (The Naval Architect, 2008)
  - Max saving on ship level of 30% (Wartsila, 2008)
- **Optimisation of superstructure:**
  - Large ships operating at high speeds – reduction potential of 2 to 5%
- **LNG potential future fuel for ships (payback dependent on fuel prices):**
  - 15% reduction potential (taking into account extra methane) (Einang and Per Mange, 2007)
- **Biofuels and other sources of propulsion?**

Questions - Marine

- In the **short-term**, there appears to be significant scope for GHG reductions with paybacks of less than 15 years – Do you agree?
- If not, where are we wrong in our numbers? Do you have other information?

- In the **longer-term**, there appears to be potential significant savings from hull redesign and engine recovery – Do you agree?
- If not, where are we wrong in our numbers? Do you have other information?

- What are the key barriers to these (short- and long-term) options?

- There appears to be limited proven, short-term potential for alternative energy carriers/fuels, other than perhaps biofuels and LNG – Do you agree?
- What are the most promising longer-term options?

Conclusions: Inland waterway, short term (existing vessels), so pre 2020

- **Improved hull designs (short payback time):**
  - Potential improvements of around 5% on existing ships
- **Optimisation of conventional propellers (short payback):**
  - Increase in fuel efficiency per vessel 20% to 30%
- **More efficient diesel engines (payback: > 10 years):**
  - Potential saving of between 15 to 20%
- **Little option for alternative energy carriers or fuels**

Conclusions: Inland waterway, long term (new vessels), so post 2020

- **Improved hull designs (short payback time):**
  - Potential improvements of between 5% to 20% possible on new ships (Wartsila, 2009)
- **Lightweight hulls (payback: > 10 years):**
  - Potential energy savings of 15% fleet-wide?? Increase in hull costs of 30%??
  - Aluminium/light weight steel: 5% fuel efficiency improvement (Wartsila, 2009)
- **Air lubrication (payback: unknown?):**
  - Potential energy savings: 17%
- **New propeller designs (unknown payback):**
  - Potential savings of up to 50% although technology not yet proven
- **Diesel electric propulsion (payback: > 10 years):**
  - Potential vessel savings: 5 to 10%
- **Larger barge units are more efficient in larger waterways (no general conclusion on payback possible):**
  - 10% increase in size leads to 4 to 5% saving in energy efficiency (Wartsila, 2009); relationship not linear, though
- **Little option for alternative energy carriers or fuels**

Questions – inland waterways

- In the **short-term**, there appears to be some potential to reduce GHG emissions – Do you agree?
- If not, where are we wrong in our numbers? Do you have other information?

- In the **longer-term**, there appears to be potentially significant GHG savings – Do you agree?
- If not, where are we wrong in our numbers? Do you have other information?

- What are the key barriers to these (short- and long-term) options?

- There appears to be limited proven, short-term potential for alternative energy carriers/fuels – Do you agree?