Assessment of greening technologies for the IWT sector

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WORKSHOP ON MODERNISATION OF DANUBE VESSELS FLEET
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• Promoting Innovation in the Inland Waterways Transport Sector

• Funded under the EU H2020 research and innovation program (budget: ca. 6.5 Mill EUR)

• Duration: 1.5.2015 – 30.4.2018

• In total: 17 beneficiaries
• Lead: Jaap Gebraad, STC-Group (NL), Gebraad@stc-r.nl

• More information:
  • http://cordis.europa.eu/project/rcn/193260_en.html
  • http://www.prominent-iwt.eu/
Introduction (1)

- Best available greening technologies and concepts:
  - Collection and assessment
  - Part of WP1 (State of Play)

- Which technologies are available?

- What is their potential with respect to the reduction of:
  - Fuel consumption
  - GHG emissions
  - Pollutant emissions
Introduction (2)

• What is their potential with respect to wide-spread implementation?
  • Applicability to largest share of existing ship types
  • Best match with actual navigation profiles

• What is their potential regarding:
  • Availability in time (pilot implementation till 2017, roll-out till 2020)
  • Costs (affordable prices, market maturity)?

• => Most promising technologies for further consideration
Projects considered:

- PLATINA
- PLATINA II
- MOVE IT!
- Innovative Danube Vessel
- + updates on latest developments (e.g. several reports TNO + input from partners WÄR, MUL)
- Contribution to impact assessment of measures for reducing emissions of inland navigation” (Panteia 2013)
- TEN-T LNG Masterplan project
- State of the art energy-efficient navigation (e.g. VoortVarend Besparen)

- Innovation Lab (EICB, 20 leading industrial organisations)
- Navrom + Viking Cruises

Identification of more than 70 measures!
Longlist of greening technologies - areas

- Infrastructure
  - Ports & mooring places
  - Waterway information
  - Waterway Infrastructure

- Ship related measures
  - Fleet structure
  - Fuels, **standardised solutions**
  - Propulsion system, **standardised solutions**
  - Propulsion system, propeller
  - Hydrodynamics
  - Ship structures & weight

- Ship operation
  - Sailing behaviour
  - Maintenance

- Education

- Logistics
## Longlist of greening technologies - example

<table>
<thead>
<tr>
<th>Type of measure</th>
<th>Area</th>
<th>Measure</th>
<th>Criterion 1: Emission reduction potential</th>
<th>Criterion 2a: Applicability on share of the European fleet</th>
<th>Criterion 2b: Economic potential</th>
<th>Criterion 3a: Technological Maturity (TRL)</th>
<th>Criterion 3b: Non-technical Maturity &amp; other hindrances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrastructural</td>
<td>Ports &amp; mooring places</td>
<td>Shore side power</td>
<td>5%</td>
<td>1</td>
<td>n.a.</td>
<td>5</td>
<td>reg. &amp; fin.support</td>
</tr>
<tr>
<td>Waterway information</td>
<td>Optimisation of locking procedure / traffic mgt.</td>
<td>5%</td>
<td>1</td>
<td>n.a.</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waterway infrastructure</td>
<td>Better pred. of av. water depth (c.f. load factor)</td>
<td>10%</td>
<td>1</td>
<td>n.a.</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Electronic ECDIS charts with actual depth information</td>
<td>5%</td>
<td>1</td>
<td>n.a.</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Real time info on fairw. data (link to energy, eff. nav.)</td>
<td>10%</td>
<td>1</td>
<td>n.a.</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Improve fairway conditions (upgrading)</td>
<td>65%</td>
<td>1</td>
<td>n.a.</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Technologies for waterway maintenance</td>
<td>n.a.</td>
<td>1</td>
<td>n.a.</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ship-related structure</td>
<td>Fleet structure</td>
<td>Use larger vessel units</td>
<td>75%</td>
<td>2</td>
<td>n.a.</td>
<td>9</td>
<td>overcapacity</td>
</tr>
<tr>
<td></td>
<td>Use more coupled convoys</td>
<td>20%</td>
<td>2</td>
<td>7</td>
<td>9</td>
<td>overcapacity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lengthening (+25%; Europe type vessel) + nozzle</td>
<td>15%</td>
<td>2</td>
<td>26</td>
<td>9</td>
<td>overcapacity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lengthening (+10%; smaller than Europe type vessel)</td>
<td>5%</td>
<td>2</td>
<td>26</td>
<td>9</td>
<td>overcapacity</td>
<td></td>
</tr>
<tr>
<td>Fuels, standardised solutions</td>
<td>Use LNG (Liquefied Natural Gas) (PM reduction)</td>
<td>90%</td>
<td>2</td>
<td>n.a.</td>
<td>5</td>
<td>reg. &amp; fin.support</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Apply dual fuel (LNG and diesel) (PM reduction)</td>
<td>90%</td>
<td>1</td>
<td>n.a.</td>
<td>5</td>
<td>reg. &amp; fin.support</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Apply GTL fuel (PM reduction)</td>
<td>60%</td>
<td>1</td>
<td>n.a.</td>
<td>9</td>
<td>reg. &amp; fin.support</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Apply CNG (PM reduction)</td>
<td>95%</td>
<td>3</td>
<td>n.a.</td>
<td>5</td>
<td>reg. &amp; fin.support</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Apply Methanol (PM Reduction)</td>
<td>95%</td>
<td>1</td>
<td>n.a.</td>
<td>3</td>
<td>reg. &amp; fin.support</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Use hydrogen / fuel cells</td>
<td>100%</td>
<td>1</td>
<td>n.a.</td>
<td>2</td>
<td>reg. &amp; fin.support</td>
<td></td>
</tr>
</tbody>
</table>

**TRL 5 - Validation**: large scale prototype / tested in relevant environment
Short list of greening technologies (1)

- **Focus:**
  - Fuels
  - Propulsion systems, standardised solutions (as listed in longlist)
  - Ship-operational measures

- **Criterion 1:**
  - Energy consumption and emissions: > 5 %

- **Criterion 2:**
  - Range of impact: economic* and technical feasibility: >10 % of fleet

- **Criterion 3: availability for mass implementation:**
  - Technological maturity: TRL > 4
  - Non-technical maturity: Overcapacity to be avoided

* Payback of 10 years not viable!
# Shortlist of greening technologies (2)

<table>
<thead>
<tr>
<th>Type of measure</th>
<th>Area</th>
<th>Measure</th>
<th>NOx</th>
<th>PM</th>
<th>CO2 only</th>
<th>GHG (CO2 &amp; CH4)</th>
<th>Applicability on the fleet</th>
<th>Economic feasibility (ship owner)</th>
<th>Technical maturity</th>
<th>Non-techn. maturity (barriers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ship-related technical measures</td>
<td>Fuels, standardised solutions</td>
<td>Use LNG (Liquefied Natural Gas) - single fuel/ spark ignition</td>
<td>70-80</td>
<td>up to 95</td>
<td>20-25</td>
<td>0-10</td>
<td>10 - 50%</td>
<td>++</td>
<td>6</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Apply dual fuel (LNG and diesel)</td>
<td>50-65</td>
<td>50-90</td>
<td>20-25</td>
<td>0-10</td>
<td>10 - 50%</td>
<td>++</td>
<td>6</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Apply GTL fuel</td>
<td>10</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>&gt; 50%</td>
<td>-</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Propulsion system, standardised solutions</td>
<td>Apply SCR</td>
<td>70-90</td>
<td>0-20</td>
<td>= 0</td>
<td>= 0</td>
<td>10 - 50%</td>
<td>--</td>
<td>8</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wall flow DPF</td>
<td>0</td>
<td>90</td>
<td>= 0</td>
<td>= 0</td>
<td>10 - 50%</td>
<td>---</td>
<td>7</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Combine SCR and DPF</td>
<td>80-90</td>
<td>90</td>
<td>= 0</td>
<td>= 0</td>
<td>10 - 50%</td>
<td>---</td>
<td>7</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Exchange of main diesel engine (CCR I by CCR II engine)</td>
<td>15-35</td>
<td>40-60%</td>
<td>0</td>
<td>0</td>
<td>&gt; 50%</td>
<td>0/-</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Exchange of main diesel engine (by Stage V engine)</td>
<td>65</td>
<td>80-90</td>
<td>0</td>
<td>0</td>
<td>&gt; 50%</td>
<td>-</td>
<td>5</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Right sizing</td>
<td>0-10</td>
<td>0-10</td>
<td>0-10</td>
<td>0-10</td>
<td>100%</td>
<td>++</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Diesel-hybrid prop. {no buffer batt.}*</td>
<td>0-10</td>
<td>0-10</td>
<td>0-10</td>
<td>0-10</td>
<td>10 - 50%</td>
<td>+</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Diesel-hybrid prop. {+ buffer batt.}*</td>
<td>0-10</td>
<td>0-10</td>
<td>0-10</td>
<td>0-10</td>
<td>10 - 50%</td>
<td>+</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>Waterway information</td>
<td>Real time info on fairw. data</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&gt;50%</td>
<td>+</td>
<td>5/7</td>
<td>-</td>
</tr>
<tr>
<td>Ship-operational measures</td>
<td>Sailing behaviour</td>
<td>Speed adaption</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&gt;50%</td>
<td>+</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Optimised track choice</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&gt;50%</td>
<td>+</td>
<td>5</td>
<td>-</td>
</tr>
</tbody>
</table>
Fact sheets

### MEASURE: (example: LNG fuel)

#### Description of Technology

Liquefied natural gas or LNG is natural gas that has been converted to a liquid form for the ease of storage or transport by cooling natural gas to approximately \(-162 \, ^\circ C\). Afterwards, it is stored at essentially atmospheric pressure. Liquefied natural gas takes up about one six hundredth the volume of natural gas in the gaseous state.

#### Impacts

- **Effects on energy consumption (fuel) and emissions**
  - Energy consumption (%)
  - GHG emissions (CO2, CH4)
  - Air pollutant emissions (NOx, PM)
  - Emission limits that could be achieved
- **Range of impact: Technical feasibility**
  - Technical applicability to fleet families (link to SWP 1.1)
  - Technical requirements for installation (e.g. required space, type/age and state of the engine etc.)
  - Possible combination with other technologies and achievable results
- **Range of impact: Economic feasibility for the ship owner**
  - Investment needed (e.g. ratio of investment related to the capital value of the vessel)
  - Impact on revenues (e.g. higher payload, more trips)
  - Share of savings on annual operational variable costs (%)
  - Risk of investment (sensitivities, uncertainties)
  - Payback period
- **Availability for mass implementation by 2020**
  - Technology status (TLR level)
  - Non-technological maturity, barriers and requirements: Legal, financial, knowledge, market, culture, others

#### Points of Attention

- Summary of main aspects for quick overview
Conclusions (1)

• LNG:
  • mainly for large vessels
  • savings in fuel costs => high investment costs (LNG tank and fuel system) earned back
  • limited number of vessels suitable for LNG
  • 100% LNG engine is risky (price LNG and Diesel)
  • dual fuel engine is more likely to be selected
  • => reduce costs by means of standardisation (dual fuel engine)
  • => validate in the pilot LNG

• SCR, DPF
  • cost-effective solution to reduce NOx and/or PM emissions for all vessels, and is attractive for environmentally
  • additional costs: urea, maintenance, no cost-benefit to ship owner!
  • cost reductions by means of standardisations and development of modular systems
Conclusions (2)

• Energy-efficient navigation
  • promising technology
  • great number of sailing hours and high fuel consumption
  • push boats and large motor vessels
  • changing waterway conditions (strongly influencing fuel consumption)
  • payback time: depend on the fuel consumption savings

• Hybrid drive trains and right sizing:
  • economics: specific journey, operating profile
  • niche solutions rather than large scale applications
  • little effect on air pollutant emissions

• GTL and replacement CCNR II engines
  • reduce emissions, but are
  • not stand-alone solutions to reach the PROMINENT targets
  • Cost-effective solution in terms of costs per kg + possible combination with other technologies => to be further investigated
Thank you for your attention!

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