Green Technologies and Eco-Efficient Alternatives for Cranes and Operations at Port Container Terminals

GREENPORT CONGRESS
Barcelona, 16th October 2014
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1. Project Overview
2. Why GREENCRANES?
3. Project Activities
4. Beyond GREENCRANES
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1. Project Overview
2. Why GREENCranes?
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4. Beyond GREENCranes
GREENCranes is a pilot action involving three Member States: Spain, Italy and Slovenia, including public administrations, strategic ports, port industrial partners and innovation centres.

Project Consortium

External Companies

Green Technologies and Eco-efficient Alternatives for Cranes and Operations at Port Container Terminals
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2. Why GREENCRANES?

Why GREENCRANES?

Industry and transport sectors in Europe are evolving towards a low-carbon emission operative model.

Technologies based on alternative fuels and advanced energy control and management systems are mature and applied in other fields.

There is gap between the research developed in ports in the last decade and the application of innovative solutions able to reduce GHG and pollutant emissions.

There is also a lack of collaboration among ports which makes difficult the effective exchange of knowledge.
2. Why GREENCRANES?

General Objective:

Facilitate the transition of the port industry to a low-carbon emission operative model

Specific Objectives:

- Demonstrate financial, technical and environmental feasibility for the adoption of Eco-Efficient Alternatives at European Port Container Terminals based on alternative fuels and smart energy management
- Test by means of real life pilots those Eco-Efficient Alternatives with high potential of fast market adoption and deployment in real installations
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Consumer Centres at Port Container Terminals

Container Terminal Machinery and Equipment

- Ship-to-Shore Crane
- Reefer Containers
- Offices
- Rubber Tyred Gantry Crane (RTG)
- Terminal Tractor
- Reach Stacker
- Empty Forklift
- Lightning
Activity 1. Mapping of Port Container Terminals Energy Profile

How Much Energy? Electrical Consumption

<table>
<thead>
<tr>
<th>Energy Consumption</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>12,522,629 kWh</td>
<td>43%</td>
</tr>
<tr>
<td>11,006,280 kWh</td>
<td>37%</td>
</tr>
<tr>
<td>4,801,013 kWh</td>
<td>15%</td>
</tr>
<tr>
<td>1,815,477 kWh</td>
<td>5%</td>
</tr>
</tbody>
</table>

Total Electrical Consumption: 30,145,399 kWh (30.1 GWh)

Carbon Footprint (Electricity): 4.15 Kg CO2eq / TEU
Activity 1. Mapping of Port Container Terminals Energy Profile

How Much Energy? Fuel Consumption

<table>
<thead>
<tr>
<th>Activity</th>
<th>Energy Consumption</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4,049,138 L</td>
<td>58%</td>
</tr>
<tr>
<td></td>
<td>2,245,147 L</td>
<td>32%</td>
</tr>
<tr>
<td></td>
<td>611,460 L</td>
<td>9%</td>
</tr>
<tr>
<td></td>
<td>80,819 L</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td><strong>6,986,564 L</strong></td>
<td><strong>90%</strong></td>
</tr>
</tbody>
</table>

Carbon Footprint (Fuel): 7.57 Kg CO2eq / TEU
Activity 1. Mapping of Port Container Terminals Energy Profile

Where is the energy consumed?
Activity 2. Evaluation of Eco-Efficient GREENCRANES Alternatives

Financial, Technical and Environmental Evaluation

Activity 2 developed an integral evaluation with the aim of adapting existing solutions based on innovative low-carbon emission technologies and alternative fuels for PCTs equipment and handling machinery. The adoption of these technologies would significantly reduce the global carbon footprint of port container installations.

- LNG Implementation in Terminal Tractors
- Eco-Fuels Reach Stacker Retrofitting
- Rubber-Tyred Gantry (RTG) cranes Retrofitting
- Application of fly-wheel technologies to RTGs
- Implementation of Energy Management Systems
Activity 2. Evaluation of Eco-Efficient GREENCRANES Alternatives

Please select a model below:

**SINGLE-VARIABLE MODEL**

- LNG TERMINAL TRACTOR
- RTG RETROFITTING MODEL

**TWO-VARIABLE MODEL**

- RTG ELECTRIFICATION MODEL
Activity 3. Pilots and Demonstrations

Eco-RTG Gen-Set Downsizing

LNG Terminal Tractor

Dual-Fuel Reach Stacker

Energy Monitoring System
Activity 3. Pilots and Demonstrations

ECO-RTG GEN-SET DOWNSIZING

Green Technologies and Eco-efficient Alternatives for Cranes and Operations at Port Container Terminals
ECO-RTG Gen-Set Downsizing

![Graph showing ECO-RTG Gen-Set Downsizing with data points for Operational Overrun, Energy Fuel Cost, and Total Operative Cost.]

Activity 3. Pilots and Demonstrations

Operative Cost €/h RTG vs Engine Power (kW)

- Current Situation: 28.42 l/h
- Pilot I: 22.36 l/h
- Pilot II: 15.6 l/h

Optimum Point

Sea Terminals

Operational Overrun
Energy Fuel Cost
Total Operative Cost
ECO-RTG Gen-Set Downsizing

**Old Generation RTG Consumption (l/h)**

- **Current Situation**: 30 l/h
- **Pilot I**: 20 l/h
- **Pilot II**: 15 l/h

- **45% Decrease in Fuel Consumption**
- **Emissions Reduction**

- **Fuel Cost €**
Green Technologies and Eco-efficient Alternatives for Cranes and Operations at Port Container Terminals
LNG Terminal Tractor Prototype

Design

Manufacturing

On-Site Deployment
LNG Terminal Tractor Prototype Design Requirements

- 3.500 mm wheelbase
  Instead 3.300 mm standard

- Hydraulic tank, battery and air compressor moved to the same side

This side free to install the 323 liters LNG tank
Activity 3. Pilots and Demonstrations

LNG Supply Mobile Station
Public Demonstration Day Valencia - December 2013
Activity 3. Pilots and Demonstrations

Emissions Measurements

TERMINAL TRACTORS FLEET 2012 (67 UNITS). CO₂ REDUCTION (TONNES)

- Diesel: 5.203 Tonne
- LNG: 4.371 Tonne

16% Decrease Fuel Cost € Emissions
## Emissions Measurements

<table>
<thead>
<tr>
<th></th>
<th>Particulate (g/h)</th>
<th>NOx (g/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st G</td>
<td>VOLVO 720 TAD (Stage II)</td>
<td>9.6</td>
</tr>
<tr>
<td>2nd G</td>
<td>VOLVO 750 TAD (Stage IIIA)</td>
<td>8.8</td>
</tr>
<tr>
<td>3rd G</td>
<td>CUMMINNS QSB 6.7 (Stage IIIA)</td>
<td>11.6</td>
</tr>
<tr>
<td>4th G</td>
<td>CUMMINNS ISB6.7E5-225 (Stage IIIB)</td>
<td>1.0</td>
</tr>
<tr>
<td>Gas 2nd</td>
<td>CUMMINNS ISL9 G 250 (Stage IV)</td>
<td>0.0</td>
</tr>
</tbody>
</table>
### Average Consumption Results

<table>
<thead>
<tr>
<th></th>
<th>Fuel (l/h; kg/h)</th>
<th>Energy (kwh/h)</th>
<th>Autonomy (h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st G VOLVO 720 TAD (Stage II)</td>
<td>8.2</td>
<td>88</td>
<td>18-20</td>
</tr>
<tr>
<td>2nd G VOLVO 750 TAD (Stage IIIA)</td>
<td>7.5</td>
<td>81</td>
<td>20-22</td>
</tr>
<tr>
<td>3rd G CUMMINS QSB 6.7 (Stage IIIA)</td>
<td>6.3</td>
<td>68</td>
<td>+24</td>
</tr>
<tr>
<td>4th G CUMMINS ISB6.7E5-225 (Stage IIIB)</td>
<td>5.7</td>
<td>61</td>
<td>+24</td>
</tr>
<tr>
<td>Gas 2nd CUMMINS ISL9 G 250 (Stage IV)</td>
<td>6.9</td>
<td>101</td>
<td>17-18</td>
</tr>
</tbody>
</table>
Business Case LNG vs. Road Diesel at Europe

Fleet: 65
IRR: 12%

Fleet: 51
IRR: 14%

Fleet: 20
IRR: 25%

Fleet: 20
IRR: 24%

Fleet: 14
IRR: 28%

Fleet: 12
IRR: 35%

Fleet: 6
IRR: 63%
Quick Deployment of GREENCRANES Products in the Port Sector

LNG tractors for new Turkish terminal

08 Jul 2014

Netherlands-based Terberg Benschop is to supply 40 LNG tractors for Asyaport's new container terminal, being built in Turkey on the Marmara Sea.

The YT222 tractors with 170kW Mercedes engines are powerful enough to handle two trailers carrying 20 inch containers.

Asyaport says it chose LNG as a fuel for its environmental properties and the fact that it's considerably cheaper in Turkey than diesel. There is also an LNG filling station near the terminal, so maintenance is easy.

Terberg's Turkish distributor Portunus, based in Istanbul, will provide service and support. Delivery will begin in January 2015.

Asyaport's new deep-water container terminal is strategically located as a transhipment hub for containers destined for the Black Sea via the Bosphorus. It will handle vessels carrying up to 18,000 teu and will have an annual capacity of around two million teu.

Investors in the terminal include Terminal Investment Ltd SA (TIL), the terminal operating subsidiary of Mediterranean Shipping Company (MSC), and the Seyir Group in Turkey.

Following this order, Terberg will also supply 29 tractors to TIL's terminal at Lome in Togo, West Africa.

Terberg to supply LNG tractors to Turkish terminal

04 Jul 2014 - Terminal Handling

Netherlands-based specialist vehicle manufacturer Terberg Benschop has been chosen to supply 40 LNG-powered tractors for a new, sophisticated container terminal in Turkey.

The Terberg YT222 tractor has a 170kW Mercedes engine, claimed to be powerful enough to handle two trailers carrying 20ft containers. Servicing and support for the tractors will be provided by Portunus – Terberg Benschop's Istanbul-based Turkish distributor.

LNG was chosen to power all tractors at the terminal as it eliminates particulate emissions and leads to much lower NOx emissions than diesel. Furthermore, LNG is considerably cheaper in Turkey than diesel and there is an LNG filling station close to the terminal. Delivery of the tractors will commence in January 2015.

To be built by Asyaport on a deep water site, the new terminal will be located around 135km from Istanbul on the Sea of Marmara. The proposed port will be strategically located as a trans-shipment hub for containers destined for the Black Sea via the Bosphorus, and will handle 18,000 TEU vessels. It will have an annual capacity of around two million TEU.

For further information on Terberg Benschop, click here
LNG DUAL-FUEL REACH STACKER
Results of Bench Tests

- The dual fuel powered engine does not show any decrease of power compared to diesel, even at maximum load.
- Diesel substitution rate varies from 60% at low rpm to 35% at high rpm (at maximum load).
- Oil temperature, exhaust temperature and intake manifold pressure don’t show significant differences between the dual fuel powered engine and the diesel powered engine.
### Pilot Results

<table>
<thead>
<tr>
<th>Fuel Average Consumption</th>
<th>Diesel</th>
<th>Dual Fuel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average substitution rate of 50%</td>
<td>16 l/h</td>
<td>Diesel 8 l/h LNG 7 kg/h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CO₂ Reduction</th>
<th>Diesel</th>
<th>Dual Fuel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average CO₂ emissions reduction 8%</td>
<td>42.6 Kg/h**</td>
<td>39.3 Kg/h**</td>
</tr>
<tr>
<td>Average per year 15,000 Kg</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Economic Results</th>
<th>Diesel</th>
<th>Dual Fuel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel cost savings 21%</td>
<td>ú 19.2*</td>
<td>ú 15.2*</td>
</tr>
<tr>
<td>average per year from ú 18,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Diesel costs in Italy 1.2 €/l; LNG costs 0.8 €/l
** 2.566 kg CO₂/l of LNG; 2.663 kg CO₂/l of Diesel
REAL TIME ENERGY MANAGEMENT SYSTEM
Port of Koper - Energy Monitoring System
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Smart, Energy Efficient and Adaptive Port Terminals
Implementing Bodies:

Green Technologies and Eco-efficient Alternatives for Cranes and Operations at Port Container Terminals
SEA TERMINALS: Three Complementary Approaches for European Ports

Â Smart Energy Management: Integral Monitoring of Container Terminal (Energy + Operations)
  - Design, prototyping and deployment of a Smart, Energy Efficient and Adaptive Management System – SEAMS Platform
  - Integral Monitoring of Port Container Terminal: SEAMS Platform + BlackBox Concept

Â Deployment and Demonstration of Last Generation Low/Zero Emission Prototypes
  - Full Electric Terminal Tractor (SEA-eTractor)
  - Hybrid (SEA-HRTG) and Dual-Fuel (SEA-DFRTG) Rubber Tyred Gantry Crane
  - Eco-Efficient Reach Stacker (SEA-EcoRS) and ForkLift (SEA-EcoLIFT)
  - Terminal Dynamic Illumination (SEA-Light)
  - LNG Supply Mobile Module Designed for Port Operations

Â Facilitation and Development of an LNG Supply Network for European Ports
Smart, Energy Efficient and Adaptive Port Terminals – SEA TERMINALS

Terminal Operation System (TOS)

Operation Order ↔ Machine Assignment

SEA TERMINALS CONCEPT

Smart, Energy-Efficient and Adaptive Management System (SEAMS)

Operational Mode ↔ Machine Status

BLACK BOX Concept

SEA STS Crane
SEA Eco-RTG
SEA Electrical Terminal Tractor
SEA Eco Reach Stacker
SEA Eco Front Lift
SEA Dynamic Lightning
Smart, Energy Efficient and Adaptive Port Terminals – SEA TERMINALS

Hybrid / LNG Dual Fuel RTG  Full Electric Terminal Tractor  Eco - Reach Stacker

Dynamic Lighting Management  LNG Supply Mobile Station for Ports
Expected Results

- Contribution to a progressive and quick decarbonisation of port container activities in Europe, thus reducing GHG and pollutant emissions.

- Demonstration of feasibility (financial, technical and environmental) of mature integrated solutions based on smart energy management, eco-efficient technologies and alternative fuels applied to port machinery and equipment.

- Provision of an innovative and market-sided approach in the way that energy is managed at port terminals, considering it as key driver for improving operations and competitiveness.

- Promotion of a collaborative framework among ports, port operators and equipment manufacturers, thus establishing new relationships not only based on commercial interests but also on common innovation opportunities.

- Transfer of the project outputs to as many as possible stakeholders at European level in order to accelerate the evolution of the port sector towards a low-carbon emission operative model.
THANKS FOR YOUR ATTENTION!

GREENCRAINES, AN ACTION DEVELOPED THANKS TO:

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