Real – Time Energy Consumption Monitoring System

Boštjan Pavlič
(Luka Koper - Port of Koper)

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

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- Introduction – Port of Koper/Container terminal
- Container terminal machinery and energy balance
- Planning the prototype
- Installation and programming: Challenges of an ad-hoc system
- Quality systems and energy efficiency
- Conclusion and future challenges
Introduction – Port of Koper/Container Terminal, key facts

- Quayside 596 m
- Max. allowed draft – 11.4m
- Berths: 3
- Railway tracks: 2x 671m, 1x 647 m, 2x 270 m
- Total terminal area: 270,000 m²
- Storage capacity: 26,500 TEUs (full & empty)
- Est. total annual capacity: 750,000 TEUs
### Container terminal machinery

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Lift Capacity (in tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4x STS panamax cranes</td>
<td>40/45 under spreader</td>
</tr>
<tr>
<td>4x STS post-panamax cranes (outreach 51m)</td>
<td>51/65 under spreader</td>
</tr>
<tr>
<td>16x rubber-tyred G/C (storage area)</td>
<td>40</td>
</tr>
<tr>
<td>2x rubber-tyred G/C (railway tracks)</td>
<td>40</td>
</tr>
<tr>
<td>11x reach stackers</td>
<td>42 - 45</td>
</tr>
<tr>
<td>7x ECH – empty container handler</td>
<td>7 - 9</td>
</tr>
<tr>
<td>46x yard trucks and 49x trailers</td>
<td></td>
</tr>
<tr>
<td>3x tugmaster (tractor)</td>
<td>25 (on 5th wheel)</td>
</tr>
</tbody>
</table>
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Container terminal energy balance

Energy balance:

Energy in 2013; Port of Koper: Fuel and Electricity

- Fuel: 67%
- Electricity: 33%

Consumption on the Container Terminal

- Fuel: 82%
- Electricity: 18%

Energy balance:

Electricity (kWh):

- 2008: 3,000,000
- 2009: 2,000,000
- 2010: 1,000,000
- 2011: 5,000,000
- 2012: 4,000,000
- 2013: 3,000,000

Fuel (l):

- 2008: 1,000,000
- 2009: 500,000
- 2010: 1,500,000
- 2011: 2,000,000
- 2012: 2,500,000
- 2013: 2,000,000
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Container terminal energy balance (2)

2011
- Ro-Ro Tractors; 0,1%
- Yard Tractors; 31,0%
- Reach Stackers; 20,0%
- Empty Container Forklifts; 7,0%
- RTG; 33,0%

2012
- Ro-Ro Tractors; 0,2%
- Reach Stackers; 19,0%
- Empty Container Forklifts; 6,6%
- Yard Tractors; 33,3%
- Road Tractors; 2,1%
- RTG; 36,8%

2013
- Ro-Ro Tractors; 0,1%
- Reach Stackers; 20,1%
- Yard Tractors; 37,3%
- Road Tractors; 0,007%
- Empty Container Forklifts; 6,4%
- Other, Frigo Genset, Cars; 1,4%
- Other, Frigo Genset, Cars; 1,4%
- RTG; 34,7%
Container terminal energy balance (3)

2011

Ship to shore cranes: 43%
Reefer containers: 26%
Outdoor lighting: 21%
Administrative building: 3%
Cathodic protection: 2%
Other: 5%

2014 (1-4)

Ship to shore cranes: 46%
Reefer containers: 21%
Outdoor lighting: 24%
Administrative building: 3%
Cathodic protection: 2%
Other: 5%
## Container terminal energy balance (4)

<table>
<thead>
<tr>
<th></th>
<th>Consumption</th>
<th>Unit</th>
<th>TJ/T</th>
<th>GWh/T</th>
<th>CO₂ emissions</th>
<th>Cost</th>
<th>Specific price</th>
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<tbody>
<tr>
<td><strong>2011</strong></td>
<td></td>
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<td></td>
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<tr>
<td>Container terminal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical energy</td>
<td>5.350.325</td>
<td>kWh</td>
<td>19.26</td>
<td>5,350</td>
<td>2.943</td>
<td>447.199</td>
<td>83,6</td>
</tr>
<tr>
<td>Fuel</td>
<td>2.349.483</td>
<td>l</td>
<td>82.21</td>
<td>22,837</td>
<td>6.166</td>
<td>2.409.963</td>
<td>105,5</td>
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<tr>
<td>Water</td>
<td>4.174</td>
<td>m³</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>7.886</td>
<td></td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td></td>
<td></td>
<td>101.47</td>
<td>28,19</td>
<td>9.109</td>
<td>2.865.048</td>
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</table>

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<th>Cost</th>
<th>Specific price</th>
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<tbody>
<tr>
<td><strong>2013</strong></td>
<td></td>
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</tr>
<tr>
<td>Electrical energy</td>
<td>4.767.256</td>
<td>kWh</td>
<td>17.16</td>
<td>4.767</td>
<td>2.622</td>
<td>392.496</td>
<td>82,3</td>
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<tr>
<td>Fuel</td>
<td>2.193.889</td>
<td>l</td>
<td>76.76</td>
<td>21,325</td>
<td>5.758</td>
<td>2.465.698</td>
<td>115,6</td>
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<tr>
<td>Water</td>
<td>6.368</td>
<td>m³</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>14.652</td>
<td></td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td></td>
<td></td>
<td>93.93</td>
<td>26,09</td>
<td>8.380</td>
<td>2.872.846</td>
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</table>

**Specific fuel consumption**

**Specific electrical energy consumption**

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Despite huge policy efforts, the EU is far from reaching its 2020 energy savings target

Projected gap in Mediterranean countries is even bigger (having in mind consequences of the economic and financial crisis)

There is a need for new, innovative, efficient and effective instruments and measures
There is a need for Integrated Performance Measurement System – **Energy and Environmental Management System (EEMS)**

Port of Koper sees **EEMS** as a tool for achieving targets and objectives related with the overall competitiveness through the **system of metering, monitoring, and evaluation of energy and environmental performance**.

Implementation in phases, bottom – up approach, in the first phase EEMS has been implemented on the Container Terminal.
Alternative – fuel switch, use of the compressed natural gas or LNG instead of diesel fuel

Natural gas network in the Obalno-Kraška (Coastal-Karst) region - current situation, no natural gas network (left) and expected future situation in 2020, new connection M6* (right)

* Source: Geoplin plinovodi, Družba za upravljanje s prenosnim omrežjem d.o.o. Razvojni načrt prenosnega plinovodnega omrežja za obdobje 2011 – 2020 (Razširjeni povzetek)
Another alternative – **Electrification of all operation at the Container Terminal**

- Excellent potential for the energy and environmental improvements
- In comparison with the current situation electrification can bring **energy savings** and **emission reductions** for **up to 80%**
- Significant noise level reduction
- Problem - Connection on the 110 kV grid:
  - High costs
  - Insufficient spatial planning – slow procedures
Alternative fuels and scenarios (3)

Future opportunities: electrification

- Two possibilities for the connection on the 110 kV grid – RTP Dekani and/or RTP Koper

- It is estimated (according to the initial consultation with system operator) that this connection can be realized in next 5 to 7 years (up to 2020)
Evaluation of the flywheel technology in the process of energy recovery and storage in a mobile gantry cranes

- Investigation of the energy recovery and storage technologies for electric power applications in ports – flywheel biggest potential for applicability on RTG cranes
- Already some implementations in transport/ports
- The main advantages of flywheel storage systems are the high charge and discharge rates for many cycles

Main components of the flywheel storage system
When flywheels are used with an RTG crane, two units are employed; a single unit provides isolated energy storage to an individual hoist motor drive. The two units are packaged together and installed underneath a crane support beam.
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**Alternative fuels and scenarios (6)**

**Case study: flywheel technology**

- **RTG cranes** — main consumers of diesel fuel and major contributor of diesel emissions at the Port of Koper

- Cost benefit analysis:
  - Without genset change - **not commercially justifiable**
  - with genset downsizing – **payback period 7 – 10 years**
Planning the prototype

- Establishing a system for measuring fuel consumption in the transport machinery (10 meters)
- Establishing a system for detailed monitoring of electricity use (17 measuring points)
- Establishing a system of measurement and transmission of data on energy use from 7 RTG
- Integration of existing information systems to support energy management

Objectives of the project:

- Clear definition of responsibilities and empowerment of workers, who operate machines and work on the shop floor, to achieve enduring performance improvements
- Introduction of new indicators (KPIs) that will accurately show the quality of the organization and work at the Container Terminal
- Preparation of methodology for the introduction of ISO 50001 at the Container Terminal
Installation the prototype - fuel consumption (l) – minute level
Installation the prototype - electricity
Installation the prototype – RTG data

Production data on 7 RTG. Internal code RTG 33 - RTG 39

Effective operating hours (h)

Fuel consumption (l)

Fuel consumption deviation from the target (l)

Fuel consumption on total operating hours (l / h)
Installation the prototype - scheme
On a daily basis monitoring the movement and the energy consumption in the container blocks.
The main benefits with the implementation of the pilot Greencranes:

- A proper knowledge about fuel and electricity consumption for each type of machinery - knowledge about energy consumption and environmental impacts
- Understanding the workload of machinery and number of movements per container blocks
- The establishment of new KPIs

2013 Electricity savings – 281.622 kWh

2013 Fuel savings – 311.767 l
An Energy Management System helps organisations to integrate energy and management into the business structures, with a purpose to save energy, save costs and improve their energy, environmental and business performance. **An Energy Management System (EMS) is a systematic process for continually improving energy performance.**

**Establishing an EMS requires you to:**
- Develop and implement an energy policy.
- Identify your significant energy use.
- Set energy objectives and measurable targets.
- Implement and operate action plan to meet these objectives and targets.
- Check and take corrective action as required.
- Review your system continually and improve where possible.
Energy and environmental management system cannot be effective without the active involvement of the top management!

**Basic scheme of Luka Koper Energy Information System**

- Production information system
  - Production extent
  - Financial data
- Energy information system
  - Energy bill data
  - Data import from old meters
  - Target lines definition
  - System administration
- Energy supervising system
  - M&T data base
  - Energy consumption data
  - Environmental data

Energy and environmental management system cannot be effective without the active involvement of the top management!
Port of Koper started with the transformation in sustainable and low carbon port!

- EEMS has been recognized as the first and necessary step in the development of sustainable port infrastructure.

- The next step will be the electrification of RTGs.

- EEMS will enable exploitation of the full potential of the Port of Koper, especially in the field of competitiveness and economic growth and reduction of negative environmental impacts.
Questions?
Thank you for your attention

bostjan.pavlic@luka-kp.si

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