The case of Warsaw: e-bus fleet extension in the context of a mixed fleet.

Comparative considerations on operational performance

26 June 2018
MZA Warsaw - one of the biggest Public Transport Operator in the region

- 1,360 buses in inventory, 1,220 on the streets daily
- 3,500 drivers
- 1,200,000 passengers daily
- 154 urban and suburban lines operated daily
- 14 night lines

<table>
<thead>
<tr>
<th>AREA</th>
<th>POPULATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>WARSAW</td>
<td>517 km²</td>
</tr>
<tr>
<td>AGGLOMERATION</td>
<td>2,730 km²</td>
</tr>
</tbody>
</table>
Bus fleet in MZA’s depots
- by European Emission Standards

* 57% - Euro V and higher standard (incl. H, LNG, EE buses)
** +10 e-buses in the depot, technical inspections done, ready to be launched
The recent fleet investments:

**Diesel:**
- Solaris U18 → 145 (Euro 6) → 2014-2016
- Mercedes-Benz Conecto → 80 (Euro 6) → 2017, 2018

**Hybrids:**
- Solaris Hybrid 18m → 4 → 2011

**Alternative drive:**
- Solbus SM18LC → 35 LNG → 2015
- Solaris U12E → 10 electric → 2015
- URSUS CS2 (12m) → 10 electric → 2017
- Solaris U18E → 1 electric (PILOT!) → 2017
- SolarisU12E → 10 electric → 2018
Diesel Engines – Euro VI

- Reliable, easy maintenance, the basis of our operation
- Photovoltaic panels
- Energy recovery system
- Less fuel consumption (4-11% compared with earlier editions of vehicles)
- Less pollution from the exhaust system
Hybrid buses

- 4 vehicles in operation since December 2011 (Solaris U18)
- 1 vehicle (Volvo 7900) – lease contract
- Proved suitable on very difficult lines (lots of passengers, frequent stops, slow motion); 10-23% less fuel consumption
Gas-powered vehicles: Solbus SM18LC

- 35 buses powered by liquefied natural gas (LNG)
- In operation for 3 years already
- Common technology in North America and China
- Short fueling procedure
- Lighter than CNG
- Less capacity of tank installation than CNG
Electric Buses in Warsaw
**Solaris Urbino 12 Electric**

- 10 vehicles since 2015
- Operating in the city centre
- Milleage: 90-115 thou. km
- Plug-in and pantograph
- Energy consumption:
  - Summer 1.26 kWh/km (+0.23)
  - Winter 2.99 kWh/km (+1.74)

**Ursus CS2 City Smile**

- 10 vehicles since 2017
- Different lines (collecting operational data)
- Milleage: 13-16 thou. km
- Energy consumption:
  - Average 1.0342 kWh/km
  - Winter 1.35 kWh/km

* 10 Solaris prepared to be launched (new technologies to be tested: high energy batteries, cooling system, SiC Inverter)
Investment costs estimated by MZA (2018):

<table>
<thead>
<tr>
<th>In mln EUR</th>
<th>12 m</th>
<th>18 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel</td>
<td>0,23</td>
<td>0,32</td>
</tr>
<tr>
<td>Hybrid</td>
<td>0,33</td>
<td>0,57</td>
</tr>
<tr>
<td>Gas: CNG/LNG</td>
<td>0,27</td>
<td>0,35</td>
</tr>
<tr>
<td>Electric</td>
<td>0,52</td>
<td>0,64</td>
</tr>
</tbody>
</table>

Operational costs for veh/km (in 2017):
Electrification plan for Warsaw:

- First fully electrified bus line since 2015,
- 21 (+10) electric buses in operation today,
- Strategy of the city: limited access for cars in the strict center, preferences for pedestrians, low-emission buses,
- Trakt Królewski (old town, historic area) as a no emission zone ➡️ EU PROJECT
„Investment in low emission bus fleet (130 low floor buses) and necessary infrastructure” - the project financed with Cohesion Fund:

- Purchase of 130 low-emission buses (2019-2020),
- Fast charging system at 15+ ends of the bus lines (pantograph chargers)
- Budget: 95 mln EUR
- EU grant: 41 mln EUR
Milestones/pilot activities for the Project:

- Feasibility Study (strategic option analysis, risk assessment, financial plan) – cooperation with JASPERS!
- Technical expertise (to decide on the battery type, check the battery life issue, make simulations on time of charging in real life conditions),
- Articulated 2 electric buses for testing in Warsaw (3 years lease) – to collect operational data
- Pantograph chargers – to collect data
Conclusions/lessons learned:

- Electrification of the bus line possible without changing the timetables (properly designed technical and operational solutions). Replacement 1:1 diesel to electric bus feasible.

- For Warsaw the most advantageous solution is a bus with "high power" batteries with energy supplementation at the ends by the pantograph charging system.

- Battery charging – 10 minutes under normal conditions, the bus leaves the end of the line with the battery charged to 80% of capacity (reserves sufficient).

- Reduction of greenhouse gas emissions by 35-40% for traction (Well-to-Wheel methodology from FS), even if the electricity in Poland comes from coal.

- Essential to choose the proper HVAC system (matched properly to the weather conditions in the city).
The MZA’s plans for electrification of the bus fleet in the years 2015 - 2020

<table>
<thead>
<tr>
<th>Year</th>
<th>Total amount of electric buses</th>
<th>Length</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>12 m</td>
<td>18 m</td>
</tr>
<tr>
<td>2015</td>
<td>10</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>21</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>2018</td>
<td>32</td>
<td>30</td>
<td>2</td>
</tr>
<tr>
<td>2019</td>
<td>102</td>
<td>30</td>
<td>72</td>
</tr>
<tr>
<td>2020</td>
<td>162</td>
<td>30</td>
<td>132</td>
</tr>
</tbody>
</table>
Thank you for your attention

Katarzyna Kwiatkowska
katarzyna.kwiatkowska@mza.waw.pl
More Information

For info or further questions on this seminar and the activities of the JASPERS Networking Platform, please contact the JASPERS Networking and Competence Centre at the following email:

jaspersnetwork@eib.org

JASPERS Networking Platform:  www.jaspersnetwork.org

JASPERS Website:  jaspers.eib.org