OPTIMISED BRAKING ENERGY RECOVERY IN TROLLEYBUS SYSTEM

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**CONTENT OF THE PRESENTATION:**

- 2011 – 2013: 1st Supercap Energy Storage System in Gdynia
- 2014 – now: 2nd Supercap Energy Storage System in Gdynia (Dyn@mo project)
- 2016 – now: Smart Grid technologies – bilaterall supply system (Eliptic project)
1ST SUPERCAP INSTALLATION FOR GDYNIA

IDEA OF PROJECT

- In 2009 Electrotechnical Institute in Warsaw (IEL) received ministerial research donation for design, developing and testing off-board energy storage system for electrical city transport

- In-door design
- Focused on energy recovery improvement
- Technical specification:
  - 4 supercap modules LS Mtron: 41 F 201,6 V
  - usable capacity: 0,7 kWh (possibility of increasing up to 1,5 kWh)
  - max. power: 300 kW
UNDER CONSTRUCTION...

SUPERCAPS MODULE INSIDE

SUPERCAPS MODULES

ASSEMBLING...
Finally in Gdynia

Supercaps
2ND SUPERCAP: DYN@MO PROJECT

- Installation of supercap storage unit in Wielkopolska substation
- This substation is located in a hilly part of Gdynia
- Capacity: 1,5 kWh
- Max. power: 500 kWh
- Supercap was made and installed by Polish company Medcom
- Outdoor – indoor instalation:
  - Control system and DC/DC converter placed inside substation
  - Supercap modules and discharged resistor placed outside substation
- In May 2013 a tender for purchase of supercapacitor was published; in July a contract for its technical project, production, delivery, assembly and installation was signed; installation took place in April 2014; supercapacitor is fully working now
BASIC SCHEME
SUPERCAP MODULES AND RESISTOR
SUPERCAP MODULES INSIDE
DC/DC CONVERTER AND CONTROL SYSTEM
DC/DC CONVERTER AND CONTROL SYSTEM
RESULTS – RECUPERATION OF ENERGY IN VEHICLES BEFORE AND AFTER SC INSTALLATION

![Graph showing recuperation percentage before and after SC installation for each month from January to December.](image-url)
Direct presentation of the savings
Utilization of recuperated energy – Smart Grid – Global system approach

Electric buses charging point

Supercapacitor energy storage

Recuperated energy

Supply system

Breaking vehicle

Accelerating vehicle
SMART GRID TECHNOLOGIES

1) charging stations for electrical buses and cars supplied from the overhead line, which may use the recuperation energy of vehicles,
2) remote control of the disconnectors system in the overhead line, enabling immediate reconfiguration of the power supply of the overhead line in the case of damage,
3) smart protection devices allowing for detection of damages in the overhead line from remote network systems,
4) bilaterral supply system
5) stationary and vehicle energy banks: supercapacitors, storage energy systems,
6) traction substation inverters to return recuperated energy to AC supply system.
Classic supply system

Substation 2

Disconnection

Recuperated energy – no flow

Breaking vehicle

Accelerating vehicle
Bilateral supply system

Substation 2

Connecting

Recuperated energy – OK!

Substation 1

Accelerating vehicle

Breaking vehicle
# Results of Modification

<table>
<thead>
<tr>
<th></th>
<th>Now</th>
<th>Super cap</th>
<th>Smart</th>
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<tbody>
<tr>
<td><strong>Power total</strong></td>
<td>58 kW</td>
<td>48 kW</td>
<td>48 kW</td>
</tr>
<tr>
<td><strong>Losses</strong></td>
<td>7 %</td>
<td>6 %</td>
<td>5 %</td>
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<tr>
<td><strong>Recuperation</strong></td>
<td>8,4 %</td>
<td>23 %</td>
<td>23 %</td>
</tr>
<tr>
<td><strong>Use of recuperation potential</strong></td>
<td>34 %</td>
<td>92 %</td>
<td>92 %</td>
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SUMMARY

- Recuperation is working, even in case of a „flat“ city
- Topology of power supply system is a very important element -> bilateral supply of trolleybus network
- Energy recuperation allows to save up to 40% of total energy costs
- Energy saved is the cheapest form of energy

Thank you for attention!

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