TrolleyMotion

New Horizons for Urban Traffic
Innovative Electric Bus Transit Systems

Session 6a:
Energy and power supply
What do electric systems cost?

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Zurich
19th November 2008
Business and socio economic approach! Only cost or overall economic result?

- Cost occur both on business and socio economic level
- Socio economics include: environment (external effects), e.g.
  - ecological balance for producing the operations include cost of producing traction energy
  - local and global emissions
  - value creation in global or local industry
  - transport of products for electric transport systems
  - increased value of real estate
- Business economic approach comprise capital expenses and operational expenditures, e.g.
  - investment
  - traction energy
  - maintenance
- Different revenue levels of transport systems have to be taken into account for overall economics
For trolley, tram and metro at least one modernisation of interior is carried out during lifetime, typically.

Diesel and gas show higher wear and tear due to vibrations and more parts with mechanical move.

Relation of investment and lifetime is much better for trolley than for tram.

Diesel: 12 bis 15 y
Gas: 12 bis 15 y
Trolley: 20 bis 30 y
Tram: 25 bis 40 y
Metro: 30 bis 40 y

Source: S2R Consulting
Trolleybuses should be used intensively in order to gain economic advantages

**Capital cost of vehicles**

- **Investment**
  - Engine, technology
  - Body, interior

- **Diesel**
- **Trolley**

### Cost structures and mechanisms

**Capital cost**

- "long lifetime"
  - Trolley-bus
  - Diesel-bus

- "heavy mileage"
  - Trolley-bus
  - Diesel-bus

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Presentation

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Infrastructure investment also has to be justified by intensive use

<table>
<thead>
<tr>
<th>Trolley-bus infrastructure</th>
<th>Initial investment</th>
<th>Total annual cost [€/km or unit]</th>
<th>Share of capital</th>
</tr>
</thead>
<tbody>
<tr>
<td>overhead contact wire system</td>
<td>~ 350 K€ p. km</td>
<td>20 - 25</td>
<td>~80%</td>
</tr>
<tr>
<td>substation</td>
<td>~ 500 K€ p.unit</td>
<td>25 - 30</td>
<td>~80%</td>
</tr>
</tbody>
</table>

Cost structures and mechanisms

Infrastructure costs are predominantly fixed costs
Vehicle and infrastructure costs are strongly correlated with the utilisation of the system
Extrapolation of energy prices shows the potential of the electrical systems

The development of energy prices is crucial for the right decision on PT systems. In ten years, the already existing difference might increase by additional 60%.

In ten years, the already existing difference might increase by additional 60%.
Increasing diesel-price makes trolley-buses more competitive

**Capital and traction energy cost**

The more intensive the use of trolley-buses the cheaper they become.

The actual advantage in traction energy sets in at approx. 58,000 km p.a.
Experiences with supercaps gain a certain cost advantage for trolleys

<table>
<thead>
<tr>
<th>Annual cost [€/km]</th>
<th>Trolley-bus</th>
<th>Trolley-bus with supercaps</th>
<th>Diesel-bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy / fuel</td>
<td>0.28</td>
<td>0.18</td>
<td>0.54</td>
</tr>
<tr>
<td>maintenance</td>
<td>0.32</td>
<td>0.32</td>
<td>0.40</td>
</tr>
<tr>
<td>capital</td>
<td>0.62</td>
<td>0.62</td>
<td>0.50</td>
</tr>
<tr>
<td>infrastructure</td>
<td>0.27</td>
<td>0.27</td>
<td>0.02</td>
</tr>
<tr>
<td>other operations</td>
<td>identical</td>
<td>identical</td>
<td></td>
</tr>
<tr>
<td>total</td>
<td>1.49</td>
<td>1.39</td>
<td>1.46</td>
</tr>
</tbody>
</table>

Business case experiences

- First time in Solingen, trolley-bus can produce services on cost level of diesel-bus
- The developments in recent years support the effect from the supercaps

Source: SW Solingen, UTP, Switzerland, 31.8.2006, own calculations
Delta in investment and operation cost focus on optimal system circumstances

**Investment expenses**

- **infrastructure:** 2x
- **vehicles:** 5x
- **metro:** 2-3x

**Operational expenditures**

- **vehicles:** 2.5x
- **tram:** 1.5x
- **metro:** 0.8x

**Presentation**

- TrolleyMotion
  - **Investment must be justified by intensive use and long life of assets**
  - Only trolley can compete with diesel bus from economic point of view
  - Tram and metro need high patronage

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**What do electric systems cost?**

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For decision making life-cycle-cost should be taken into account carefully

- Even though initial investment in trolley-buses is high, LCC can be lower than for diesel-buses
- Strong impact have the lifetime of fixed assets, the utilisation and energy cost in the respective country
- New developments and innovations support the economic situation of trolley-bus (energy price, super-caps, use of trailers, double-articulated trolleys, etc.)

Assuming the trend of energy trolley can be cheaper than diesel in terms of LCC

Cash flow analysis results in advantage of 20%
Not only cost, but performance and time to market are typical systems' criteria.

While performance can be nearly the same, realisation time and cost are one tenth for trolley compared with tram.

Metro systems is highest in all criteria.

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Summary

- Metro systems are without discussion for big cities and high passenger volume
- Between tram and trolley the gap has been narrowed due to high performance of trolley systems
- If circumstances allow for high capacity by separate lanes, green waves and appropriate stations, trolley is better choice than tram due to
  - lower investment
  - faster implementation
- Business economic advantages are possible for trolley against diesel (gas), if specific requirements are fulfilled
  - high usage of infrastructure and vehicles (fixed cost), which needs good planning (infra and operations)
  - energy cost are developing like the last years
  - opportunities of recuperation are used optimally
  - maintenance is optimised
  - rail bonus for revenues can be achieved
Summary

- Socio economic advantages are clear for electrical systems
- Keeping them in mind trolley is more than competitive for small and medium sized cities
If you have any questions or if you would like to receive further information, please do not hesitate to contact us!

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