State-of-the-Art in Light Rail Alternative Power Supplies

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Background

- Conventional OCS preferred power distribution since 1880s
- Complex subject best approached from a systems viewpoint
- Three basic types:
  - Ground Level Power Supply (GLPS)
  - Onboard Energy Storage System (OESS)
  - Onboard Power Generation System (OPGS)
- Plus hybridized combinations!
Advantages

- Improved aesthetics
- Reduction in conflicts with other users of the street space
- Potential for infrastructure simplification
Disadvantages

- Vehicle becomes more complicated; weight, space and performance trade-offs
- Onboard Energy Storage - unknown life expectancy of energy storage elements
- Ground Level Power - high cost / proprietary, complicates infrastructure
- Onboard Power Generation - hydrogen technology not mature, expensive, requires fueling
Ten years ago (2005): only one “off wire” system in commercial service (Bordeaux, using GLPS)

*Rapidly changing - today there are:*

- 8 systems using Ground Level power supply with 5 more under construction
- 9 systems using Onboard Energy Storage for off-wire with 8 more under construction
Current Status Worldwide 2

- 4 systems using Onboard Power Generation with one under construction
- Numerous systems using energy storage to achieve energy savings
- More than 27 development prototypes in last ten years!
Automotive sector driving development of energy storage devices

Battery, Super Capacitor, Flywheel and Fuel Cell technologies advanced considerably in last decade

Light rail / streetcar / tramway vehicles ideal candidate for application of OESS

Market factors slowing initial progress:
- Low production quantities
- Inherent conservatism of railcar market, where 30 year vehicle life is norm
Initial approach was to provide a continuous power supply

- Advantageous where HVAC requirements are high, steep uphill gradients, etc.
- Downside: complex ground level infrastructure is high cost / proprietary

Hybridized concept with more onboard energy storage reduces ground level infrastructure (e.g. only at stops and uphill segments)
Evolution- Onboard Energy Storage

- OESS is a non-continuous power source (requires recharging enroute)
- Charging method depends on system design:
  - Charging while under wire (for short off-wire segments)
  - “Charging station” at stops (for longer distances – ground level or overhead pick-up)
- Length of “off-wire” segments increasing on new systems
- Continuing evolution / improvement of energy storage elements
Evolution - Onboard Power Generation

- Slowest to develop due to space impacts, periodic refueling and other trade-offs
- Diesel hybrid tram-train applications
- Major hydrogen fuel cell advances on the horizon, but costs still high
Conclusions 1

- Alternative power supplies entering new phase of development; large number of “early adopter” systems now coming on line – more coming
- Energy storage devices evolving rapidly, driven by automotive sector
- Application remains very project-specific
Conclusions 2

- Commercial issues are significant
  - Little unbiased hard cost / reliability data available
  - Proprietary technology issues remain with GLPS
  - Initial and life-cycle costs still high
  - Are some solutions better suited to alternate project delivery methods?

- OESS has multiple uses – off-wire operation and energy saving (peak shaving)

- Emerging trend is OESS with periodic recharging
Parting Thoughts

- What industry R&D process changes could further speed up / improve development?
- What design and analysis tools are needed to analyze system requirements, optimize design and size vehicle OESS?
- How are standards (or lack thereof) impacting development? What new standards is the industry already working on?
- How are operational impacts being considered? (transit not known for babying equipment)
- What about specifying a vehicle capable of future off-wire upgrade?
- What is the optimal design for charging points and associated equipment?
  - Current collector up/down automation
  - Power supply/distribution to charging points