Short and long term vision on improvements in bus transport

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Short and long term vision on improvements in bus transport: possibilities

Short term:

**Any experiment with electric busses results in more knowledge:*

- electric drives,
- auxiliary equipment,
- brake energy recovery.

* *City centers, touristic areas*

* *Retrofit* with single motor? But 2 or 4 motors is better.

Longer term = rest of presentation:

A) Technical possibilities

1) City Bus

2) Long distance bus-coach

3) High efficiency and low weight electric drives

4) All transport means should reduce weight.

B) Financial and social

C) Conclusion

A) Technical possibilities

1) City bus, Battery Electric?

* Problems

- Cost and lifetime of batteries,
- Battery Management System BMS reliability
- Human resources in Power electronics

Comment:
How many battery packs for 1million km?

* Solutions to alleviate the battery problem:

+ inductive charging

+ contact charging

- plug charging is still possible in longer stops (night and at noon?)

* Other solutions?

Conventional IC engine on rear wheels, but braking energy from inertia in a small flywheel, electric drive on front wheels.

Possibility of traction control on icy roads

A) Technical possibilities

2) Long distance bus-coach

*Pure electric :

- Pure electric is not realistic for long distance

+ Battery-Electric with range extender?
For mixed use: short and long distance

* Improvement on actual (diesel) buses:

- Other fuels:
kerosene, methanol, LPG, H_2 ,CNG without methane leaks?

- Fuel additives:
flame speed improvers:
acetone, butanone, 0.1%
cetane number improvers:
alkyl nitrates,…

* Thermodynamic bottom cycle:

Recover electrical/mechanical energy from exhaust

+ Organic Rankine cycle (10-15%)

- Steam cycle (10-15%)

- Giant thermoelectric effect (<4%)

A) Technical possibilities

2) Long distance bus-coach: auxiliaries

*Generator:

Electricity about 1 euro/ kWh but poor efficiency now:

- Lundell alternator at 12V
45-55%, at full load, 50-62% at partial.
- Lundell alternator at 24V: only 8% better
- Towards 48V?

* Light

+ Led lamps for inside, outside, by preference > = 100lumen/watt is possible.

- Filament lamps: 10 lumen/watt.

- CFL and low efficiency led: 40-70 lumen/watt

* Air-co

+ On exhaust heat?

+ On PV panels at the roof?

Cooling without engine running?

At least ventilation

= increase in comfort

A) Technical possibilities

3) High efficiency and low weight electric drives

*Electric Motor:

+ *Permanent magnet*
High peak efficiency, above 95% , lowest weight, factor 1.3 constant power range.
+ *Switched reluctance* motor. max. 93% efficiency but flat, factor 4 constant power range.
- *Induction motor*
Cheaper today, lower efficiency max 91%, factor 1.5 in constant power at peak load

Efficiencies only for comparison

* Differential needed? -no-

- 4% loss in usual 90° differential.

+ Two electric motors and gear have lower weight Compared to 1 motor with differential and gear

* 2 or 4 wheel drive?

Four electric motors:

+ Less current / motor

Better traction control on ice.

- More complex electronics.

A) Technical possibilities

4) All transport means should reduce weight

*3 Benefits

- *Lower energy for acceleration*
(50% of city bus) constant power range.
- *Lower energy in rolling resistance.*
Rolling resistance some 50% at high speed (coaches)
- *Lower power in hill climbing*
Depending on the trajectory

* Possibilities

- Now about 250kg/ person.

- Ultra light vehicles can achieve (Elbev project) <100kg/person,

Why not buses?

*How?

- Chassis: lattice, alu, stainless steel…

Flexible chassis?

- Integration of electric drives in suspension

- Skin: fiber reinforced polymer

- Challenge to reduce seat weight and maintain comfort

- Auxiliaries

B) Financial and social aspects

Financial

*Investment

All proposed technical solutions needs investing in research and production before fuel saving can be achieved

* Where?

Battery buses, first in the cities centers and touristic areas

*Who?

- Cities: Exploitation/authorities: mainly cities for Battery Electric.
- Long distance Exploitation/regulations: General improvements in weight and auxiliaries:
- OEM manufacturers for component development. Who finances them?

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B) Financial and social aspects

Social

*People

People may be want more entertainment and features such as
WIFI.
= rather independent on the kind of drive system.

Fuel savings are needed for investments, so not really cheaper

* Society

+ Clean air:

Diseases
Monuments

*Exploitation

+ Cleaner image.

+ Lower gravity point with batteries.

+ More quiet operation at low speed, lower noise in the street

C) Conclusion

✓A lot of technical improvements are possible

✓Research and developments and testing needed

✓Most of improvements need first investments: Who?

Who benefits:

- society with clean air
- fuel/maintenance saving: exploitation
- minimal difference for the user.

It is too early for a clear return on investment without risk

C) Conclusion

Thanks for your attention

Accutram 1899-1904 used in
Gent, Belgium, photo Lammerstraat
http://www.sosseteit.com/Over_dialect.html

Gyrobus 1955 used in
Gent Belgium;
museum Antwerp

References

References

Own articles (converters, ultralight vehicles, electric solutions, organic rankine)

https://biblio.ugent.be/person/801000552755

Rankine cycle:
J.P. Liu, J.Q. Fu, C.Q. Ren, L.J. Wang, Z.X. Xu, B.L. Deng
Comparison and analysis of engine exhaust gas energy recovery
potential through various bottom cycles,
Applied Thermal Engineering 50 (2013) 1219e1234

Lundell alternator:
Ruben Ivankovic, Jérôme Cros, Mehdi Taghizadeh Kakhki,
Carlos A. Martins and Philippe Viarouge, "Power Electronic Solutions to Improve the Performance of Lundell Automotive Alternators"
http://www.intechopen.com/download/get/type/pdfs/id/38166

http://en.wikipedia.org/wiki/Alternator_%28automotive%29