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 1 million 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
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, H₂, 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%)
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 > = 100 lumen/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
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**

*Investment*

All proposed technical solutions need 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?
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
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