European Concept of the Urban Bus

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Bus role - more important than it looks

Stern Report

Total emissions in 2000: 42 GtCO2e.
Energy emissions are mostly CO₂ (some non-CO₂ in industry and other energy related).
Non-energy emissions are CO₂ (land use) and non-CO₂ (agriculture and waste).

Source: Prepared by Stern Review, from data drawn from World Resources Institute Climate Analysis Indicators Tool (CAIT) on-line database version 3.0.

● Bus systems are the main carriers in Public Transport
  ○ 80% of all public transport passengers worldwide are carried by buses
  ○ In Europe, every year, 30 billion of passengers take urban buses
    ○ 50% of whole PT movement
● The Bus is a very efficient mode of public transport
  ○ cheap, flexible in terms of capacity and speed.
● Bus does not require heavy infrastructure, and is easy to put in service.
● Bus still remains the most universal solution for a balanced and sustainable urban development.
● Nevertheless, bus is perceived today as a less attractive mode of public transport!
How is the European Bus System of the Future?

- An **intelligent** system...
  - efficient use of information
  - different **bus system solutions** adapted to specific needs of all stakeholders

- ...**innovative** vehicles and infrastructure...
  - providing improved **comfort** to drivers and passengers
  - providing improved **accessibility** to all the users
  - making smart use of **energy**

- ...**integrated** in the European Urban scenarios
  - adapted to different modern and historical city contexts
  - taking into account the **future mobility trends**
  - featuring **new services** for passengers and operators
  - core part of the whole transport network for citizens **seamless mobility**
Proportion of the population aged 65 and over

- Europe (1)
- Oceania
- North America
- Asia
- Latin America and the Caribbean
- Africa

Europe
Proportion of the population aged under 15

- Africa
- Latin America and the Caribbean
- Asia
- Oceania
- Northern America
- Europe (1)
Some 212 million people live in Europe’s 500 largest cities
European Bus System of the Future

Defining a new generation of bus networks for European cities and developing innovative high quality Bus System with:

• State-of-the art clean vehicles
• Buses fully integrated to the urban environment
• Services answering passengers’ needs of today and tomorrow

Additional aim:
To maintain or improve the competitive position of the European bus manufacturers and operators by promoting a new concept under the brand “the European Bus System” and by bringing together within the project the precompetitive R&D expertise of five major manufacturers.
„The whole is more than the sum of its parts”

Aristotle, Metaphysis
EBSF Partners
New, tailor-made mode of transport matching passengers’ needs

Making the bus choice!
**Taking the bus by choice and not** by obligation is still rare for European passengers.

There are too many constraints when taking urban buses to put them on an equal level of user satisfaction with cars.

Today, private modes of transport provide more customised journeys than public ones. Reversing what looks to be an urban transport principle is however feasible:

**Constraints must be removed from bus systems!**
Passengers
Bus for all means at least easy boarding facilities for all kind of passengers, dedicated spaces, e.g. for prams, wheelchairs, luggage, and priority seats for the less able bodied.

User-friendly approach, irrespective of travel time or destination. Door-to-door guidance and information must be easy to find and to understand.

Good visibility of the stops with easy access is also fundamental to enable people to identify the system.

Comfort is a crucial element to win and retain new passengers. The vehicle must be clean, not over-crowded, with efficient heating, ventilation and air conditioning.

Reliability and frequency of the service on wide coverage day-night schedules also constitute comfort criteria.

Higher speed will lead to the bus being able to compete better with the car. Boosting bus speed will generate a more efficient, more punctual and more frequent service for users. support

Car parking policy

Intermodal ticketing systems
Public transport plays a major role in society. It contributes to reducing the risk of social exclusion of isolated people and gives the whole population access to employment, education, recreation, shops and services. To fulfil its social mission, public transport has to reflect the changes in society.

The European Bus System of the Future will help European society to mirror the evolution in citizens’ expectations due to:

- **demographic changes**: elderly people are more numerous, more active and more mobile, they need transport services adapted to them
- **the growing separation of activities**, such as residential areas, shops, and administrative centres, results in more frequent and more complex trips
- **the travel patterns of workers during the week** and in the day change rapidly.
Only a **smart use of energy sources** can help to face the consequences of climate change and the limitation of energy fossil sources, which will become increasingly scarce and expensive.

Solutions to limit the negative effects of gas emissions should be encouraged such as:

- decreasing distances between activities, physically or virtually
- promoting environmentally-friendly mobility modes
- reducing fuel consumption of vehicles
- acting on the flow of vehicles with better traffic monitoring and control, thanks to dedicated bus lanes, low speed zones and high speed zones in cities.
about 70 cars \longrightarrow 1 bus

... or more
Bus systems already have an excellent environmental performance compared to individual motorised transport but further research must continue to:

- optimise clean diesel technologies
- develop alternative fuels and renewable forms of energy with particular attention to hybrid and electric solutions
- reduce noise and vibration
- produce new light-weight materials for vehicles and structural components.

A common platform to exchange experiences and best practices in bus propulsion technology and use of clean fuels needs to emerge urgently at the European level. It would generate economies of scale as well as funding instruments to help take decisions about:

- alternative fuels and renewable forms of energy, e.g. DME, biofuels, hydrogen, ethanol
- development of the second hybrid generation, combined with major efforts to make vehicles lighter.
On social aspects, the image of the bus must be very positive.

- It contributes to improving the quality of life in cities
- Buses provide flexible services
- Bus transport can be adopted to any architecture or city specific historical climate and requirements
Design solutions

Accessibility, Layout & Passenger Flow, Dwell Time

Energy Management and Energy Saving solutions

New ergonomic Driver Workplace

Fire safety

External / Internal Modularity

Lateral and Vertical Guidance to platform

Monotrack Steering Techniques

Standard IT platform on-board (Passenger info, Remote Maintenance...)

Design solutions for improving attractiveness
Design solutions

- Interexchange stations design and success factors
- Intermodality with other PT and complementary transport modes
- Transport policies and Traffic rules for urban bus services
- Efficiency of travel (information, fare collection,..., ticket validation)
- Optimisation of crossing Bus lines monitoring operations
Design solutions

- Back-Office improvements (Remote Diagnostic...)
- Bus-Stops improvements (information to passengers...)
- New scalable Bus Stop design and prototype
- Standard IT platform Test-bench
Budapest premiere of EBSF MAN bus
MAN Lion's City GL
## The technical specifications of the EBSF bus from MAN

<table>
<thead>
<tr>
<th>Model</th>
<th>MAN Lion’s City GL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>18,750 mm</td>
</tr>
<tr>
<td>Width</td>
<td>2500 mm</td>
</tr>
<tr>
<td>Height</td>
<td>2880 mm</td>
</tr>
<tr>
<td>Turning circle</td>
<td>24,428 mm</td>
</tr>
<tr>
<td>Wheelbase</td>
<td>5,875 mm forebody, 6,770 mm afterbody</td>
</tr>
<tr>
<td>Floor height</td>
<td>370 mm between Doors 1 and 5, 425 mm at the pivot</td>
</tr>
<tr>
<td>Entrance height</td>
<td>320 mm</td>
</tr>
<tr>
<td>Engine</td>
<td>MAN D20 common-rail engine using MAN PURE DIESEL® technology with variable exhaust-gas recirculation, two-stage turbocharging with intercooling and an electronically monitored CRTec® particulate filter.</td>
</tr>
<tr>
<td>Installation</td>
<td>Rear left, horizontal</td>
</tr>
<tr>
<td>Capacity</td>
<td>10,518 cm³</td>
</tr>
<tr>
<td>Output</td>
<td>253 kW / 320 hp at 1,900 rpm</td>
</tr>
<tr>
<td>Maximum torque</td>
<td>1,600 Nm at 1,000 to 1,400 rpm</td>
</tr>
<tr>
<td>Gearbox</td>
<td>4-speed automatic Voith D 864.5 with SensoTop efficiency software and integrated retarder</td>
</tr>
<tr>
<td>Drive axle</td>
<td>MAN-ZF portal axle with central drive offset to the left</td>
</tr>
<tr>
<td>Suspension</td>
<td>Roll-bellows air suspension with two bellows (front axle) and four bellows (center axle, rear axle)</td>
</tr>
<tr>
<td></td>
<td>Kneeling function: lowering by 80 mm</td>
</tr>
<tr>
<td>Tyres</td>
<td>275/70 R 22.5</td>
</tr>
<tr>
<td>Heating</td>
<td>Five fan heaters under the seats with a heating output of 4.9 kW</td>
</tr>
<tr>
<td></td>
<td>One wall-mounted fan heater with a heating output of 7,5 kW</td>
</tr>
<tr>
<td>Fuel tank</td>
<td>350 litres of diesel fuel</td>
</tr>
<tr>
<td>Capacity</td>
<td>39 seats + 1 driver, 7 folding seats, Standing room for max. 118 passengers</td>
</tr>
</tbody>
</table>
MAN design
The front section of the bus, opposite the middle door, has space for baby carriages or persons in wheelchairs. Padded rests form a comfortable standing place for accompanying persons. To make access to this area easier, the driver can fold out a mechanical ramp from this door to compensate for height differences and bridge the gap between bus and bus stop. In addition, the MAN Lion's City GL has a kneeling function enabling the right side of the bus to be lowered and the entrance height reduced from 32 to 24 centimetres. This makes boarding the bus far easier, particularly for those persons whose mobility is restricted.
The bus was modified for the research project by having five inward swinging, dual-leaf doors fitted, each of them 1.25 metres wide and fully glazed. Articulated buses usually have three or four entrances. The EBSF bus has been fitted with a new generation of doors for test purposes: they are equipped with an optimised, electrical drive mounted in the top of the rotating column. This saves space and doesn't need a complex mechanism, which in turn saves weight and reduces maintenance effort. The new doors open and close quickly, reducing the time spent at stops.
A big part in the optimised passenger flow inside the bus is played by the translucent folding bellows, which lets light into the vehicle and makes for a friendly atmosphere. In a conventional articulated bus, the area above the pivot is felt to be rather dark: here, the light changes all that. This breaks down what has in the past been a barrier for many passengers, making them unwilling to spread out evenly throughout the bus.
Prominent in both the forebody of the bus as well as on the rear wall of the afterbody are LED displays that are almost as wide as the vehicle. The screens inform the passengers about the next stop, for example. Two 17-inch widescreen 16:10 TFT monitors in the middle of the bus near the pivot provide passengers with further information and entertainment.
Driver place of work
The system provides the data measured during service periods, and is available online, helping operators to reduce maintenance costs. The use of the EBSF-defined standard communication protocol for on-board passenger information and remote diagnostics would allow the interconnection between IT devices of different manufacturers. The EBSF IT platform provides standard interfaces for onboard IP telematic architecture and standard rules for multichannel communications between vehicle and infrastructure. This flexibility responds to the needs of public transport operators and authorities by allowing the implementation of new functions and facilitating equipment/application renewal by maximising interoperability between heterogeneous systems.
The engine is coupled to the DIWA four-speed automatic transmission from Voith. Its SensoTop topographical efficiency software contributes to a reduction in consumption of around three percent. The system does this by detecting uphill and downhill slopes and seamlessly adjusting the shift points accordingly. The shift program avoids the shift-hunting that is so unpleasant for passengers by evaluating the gradient and the vehicle's acceleration. Moreover, a new, more efficient air-conditioning compressor has been installed in the EBSF bus. Although it has the same output, the new compressor is lighter than those usually installed up to now. This saving in weight has in turn a positive effect on the payload.
Tests in Budapest

The demonstrator vehicle from MAN will be tested for several months on the eleven-kilometre long Line 86 in Budapest's inner city. The route and the high passenger volume make it ideal for testing the ground-breaking concept in practice. The line has a total of 46 stops and connects to the two most important tram lines as well as to a station on the underground. Roughly 26,000 passengers use Line 86 in each direction every workday. The Budapest Transport Company has calculated that the average speed of the vehicles currently serving this route is 20 km/h, dropping to 15 km/h in heavy traffic. This means that a rapid passenger flow and thus short waits at each stop will make a significant contribution to minimising loop time. The less time needed to serve the route, the more often the route can be served each day, thus improving service to the user.
Passengers
Revised proposal for a

DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

on the promotion of clean and energy efficient road transport vehicles

(presented by the Commission)
ANNEX

Data for the calculation of external lifetime costs of road transport vehicles for the purpose of this Directive

Table 1: Energy content of motor fuels

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Energy content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel</td>
<td>36 MJ/litre</td>
</tr>
<tr>
<td>Petrol</td>
<td>32 MJ/litre</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>38 MJ/Nm³</td>
</tr>
<tr>
<td>LPG (liquefied petroleum gas)</td>
<td>24 MJ/litre</td>
</tr>
<tr>
<td>Ethanol</td>
<td>21 MJ/litre</td>
</tr>
<tr>
<td>Biodiesel</td>
<td>33 MJ/litre</td>
</tr>
<tr>
<td>Emulsion fuel</td>
<td>32 MJ/litre</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>11 MJ/Nm³</td>
</tr>
</tbody>
</table>

Table 2: Cost for emissions in road transport (in 2007 prices):

<table>
<thead>
<tr>
<th>CO₂</th>
<th>NOx</th>
<th>NMHC</th>
<th>Particulate Matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 €cents/kg</td>
<td>0.44 €cents/g</td>
<td>0.1 €cents/g</td>
<td>8.7 €cents/g</td>
</tr>
</tbody>
</table>

Table 3: Lifetime mileage of road transport vehicles

<table>
<thead>
<tr>
<th>Vehicle category (M and N categories as defined in Directive 2007/46/EC)</th>
<th>Lifetime mileage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger cars (M1)</td>
<td>200 000 km</td>
</tr>
<tr>
<td>Light commercial vehicles (N1)</td>
<td>250 000 km</td>
</tr>
<tr>
<td>Heavy goods vehicles (N2, N3)</td>
<td>1 000 000 km</td>
</tr>
<tr>
<td>Buses (M2, M3)</td>
<td>800 000 km</td>
</tr>
</tbody>
</table>
MAN D20 common-rail engine using MAN PURE DIESEL® technology with variable exhaust-gas recirculation, two-stage turbocharging with intercooling and an electronically monitored CRTec® particulate filter.
The Blue Efficiency Power engines, which share a common basic design, have been under development for five years. Features include the new X-PULSE injection system with pressure booster; an asymmetric exhaust gas turbocharger; emission control with SCR technology, EGR and a particulate filter; and a three-stage exhaust brake.

The first European member of the new engine generation is the Mercedes-Benz OM 471, with a 12.8-liter displacement. The OM 471 is the first engine in its class to have received type approval and already be available with the coming Euro VI emission standard (which begins taking effect in two years). The OM 471 has a power output range of 310 kW (421 hp) to 375 kW (510 hp) and maximum torque of between 2100 and 2500 N.m.
intake throttle to prevent cold air from flowing through the engine and into the exhaust when coasting.

NOx sensor are all integrated in the compact silencer unit. The temperature (°C) is measured all the way up to the catalysts and the pressure drop (ΔP) across the DPF monitored to assess the status of the filter.
Schematic view of engine and exhaust management

**Engine**
The flow of intake air from the variable-geometry turbocharger (VGT) can be restricted with the intake throttle to prevent cold air from flowing through the engine and into the exhaust when coasting.

**Aftertreatment**
The upstream NOx sensor, diesel oxidation catalyst (DOC), full-flow diesel particulate filter (DPF), AdBlue mixer, twin parallel SCR catalysts, ammonium slip catalysts (ASC) and downstream NOx sensor are all integrated in the compact silencer unit. The temperature (°C) is measured all the way up to the catalysts and the pressure drop (ΔP) across the DPF monitored to assess the status of the filter.
The MAN E0836 LOH 01 CNG achieves EEV exhaust values by means of a three-way catalytic converter without additives or particle filters. The new ECG4 engine control, On-Board-Diagnosis II and highly developed catalytic converter technology attain exhaust-gas values significantly better than EEV level. Thanks to the three-way catalytic converter and lambda=1 control, the new E08 engine has particularly low nitrogen oxide emissions.
The MAN E0836 LOH 01 CNG
The E0836 is a future-oriented solution to enable operation in inner-city environmental zones. Because of its ability to run on special-purpose biogas, the MAN E0836 enables a considerable reduction in CO₂ emissions. Even when operating on fossil natural gas, the CO₂ emissions are slightly lower than those of a diesel engine.

With outputs of 162 kW (220 hp) to 206 kW (280 hp) at 2,200 rpm and a weight of only 650 kg, the new E0836 engine saves up to 400 kg relative to the 199 kW (270 hp) or 228 kW (310 hp) E2876 CNG turbocharged engine. The high power density of the new E0836 natural-gas engine enables downsizing, i.e. the use of a smaller, lighter and more economical engine in the same vehicle.

Downsizing is a consistently efficient approach from MAN, aimed at reducing the total costs of ownership (TCO). Maintenance intervals of up to 30,000 km also make a contribution in this respect. Moreover, the engines are extremely maintenance-friendly, thanks to the MANcats II diagnostic system. Another detail that consistently reduces TCO.
**Ethanol as diesel fuel**

**Technical changes**
- Compression ratio raised from 18:1 to 28:1
- Larger fuel injection nozzles
- Injection timing altered
- Gaskets and filters changed
- Larger fuel tanks needed
Ethanol fuel composition

**ETAMAX D**

(in percentage by weight)

- Ethanol (hydrated, 95%) 90.2%
- Ignition Improver (Beralid 3540) 7.0%
- Denaturants
  - Methyl tert-butyl ether 2.3%
  - Iso-butanol 0.5%
- Corrosion inhibitor (Morpholine) 125 ppm
Net gain in CO2 with ethanol (Stockholm, diesel oil vs. ethanol)

120,000 tonnes CO2

Emission data from Stockholm Public Transport:
Emissions of fossil CO2 reduced by 120,000 tonnes since 1990
Net gain in PM with ethanol (Stockholm, diesel oil vs. ethanol)

Emission data from Stockholm Public Transport:
Emissions of fossil PM reduced by 25 tonnes since 1990
Net gain in NOx with ethanol (Stockholm, diesel oil vs. ethanol)

900 tonnes NOx

Emission data from Stockholm Public Transport:
Emissions of fossil NOx reduced by 900 tonnes since 1990
Ethanol bus fuel consumption

Diesel oil 40 l/100km
CNG 52 Nm/100km
E95 80 l/100km (Słupsk), 70 l/100km (Stockholm)
Ethanol as diesel fuel

Operational aspects

- Fuel handling
- Sprinkler system standard
- Shorter oil-change intervals (halved)
- More scheduled maintenance required
- Pure ethanol plus 5% ignition improver
- Diesel engine technology, high efficiency
- Liquid renewable fuel, easy to handle
- Potential for high global volumes
- Excellent emission levels
DIVA gearbox
Voith DIWA 3 automatic gearbox with retarder
Voith DIWA 3 automatic gearbox with retarder
Voith DIWA 3 automatic gearbox with retarder
**Fuel Cell Bus**

<table>
<thead>
<tr>
<th>Propulsion type (automobiles)</th>
<th>Fuel economy (mpg*)</th>
<th>Greenhouse gases (g/mile)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel</td>
<td>23.8</td>
<td>480</td>
</tr>
<tr>
<td>Diesel hybrid</td>
<td>29.4</td>
<td>390</td>
</tr>
<tr>
<td>Hydrogen fuel cell vehicle</td>
<td>43.2</td>
<td>300</td>
</tr>
</tbody>
</table>

*1 mile per gallon = 0.425143707 kilometers per liter
Hybrid bus

- Energy storage system
- Power conversion unit
- 6 cylinder CI engine
- A/C
- Generator 150 kW
- 2 electric motors (2x75kW) with planetary gear
Hybrid bus

- **Start**
  - Ultracapacitor
  - Electric motors
  - Planetary gear

- **Acceleration**
  - Ultracapacitor
  - Electric motors
  - Planetary gear

- **Drive**
  - Ultracapacitor
  - Electric motors
  - Planetary gear

- **Braking**
  - Ultracapacitor
  - Electric motors
  - Planetary gear
<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length/width/height</td>
<td>11.980 / 2.500 / 3.300 mm</td>
</tr>
<tr>
<td>Number of axles</td>
<td>2</td>
</tr>
<tr>
<td>Wheelbase</td>
<td>5.875 mm</td>
</tr>
<tr>
<td>Seats/standing places</td>
<td>28/48</td>
</tr>
<tr>
<td>Hybrid system</td>
<td>Standard full hybrid with “intelligent MAN Energy Management”</td>
</tr>
<tr>
<td>Engines</td>
<td>Vertically installed diesel engine MAN D 0836 LOH EEV, 2 asynchronous electric motors each 75 kW</td>
</tr>
<tr>
<td>Cylinders/displacement</td>
<td>R6 / 6871 cm³</td>
</tr>
<tr>
<td>Power output</td>
<td>184 kW / 250 HP @ 2300 rpm</td>
</tr>
<tr>
<td>Max. torque</td>
<td>1050 Nm @ 1200-1750 rpm; electric motors total 3.000Nm</td>
</tr>
<tr>
<td>Emissions standard</td>
<td>EEV (Enhanced Environmentally friendly Vehicle)</td>
</tr>
<tr>
<td>Exhaust gas treatment</td>
<td>MAN PURE DIESEL® technology with EGR, BiTurbo and CRTec®</td>
</tr>
<tr>
<td>Energy storage system</td>
<td>High performance capacitors “Ultracaps”, 6 air-cooled modules with a total of 200 kW output</td>
</tr>
<tr>
<td>Transmission</td>
<td>Stepless power transmission</td>
</tr>
<tr>
<td>Suspension</td>
<td>Front: MAN comfort low floor axle, rear: ZF portal axle</td>
</tr>
<tr>
<td>Braking system</td>
<td>Electronically regulated triple circuit system (EBS, ABS, ASR)</td>
</tr>
<tr>
<td>Kerb weight/gross veh. weight</td>
<td>approx. 12.6 t / 18 t</td>
</tr>
</tbody>
</table>
• Up to 30 percent reduced fuel consumption and CO2 emissions depending on use and version
• Saving of up to 26 tons of CO2 for overall vehicle depending on area of use
• CO2 emissions per person/kilometre approx. 9/20 grammes (full/half load at 30 L/100km) (Details are based on trial and test values.)
• Drive-off from bus stop practically free of noise and emissions
• Engine is switched off up to 40 percent of operating time thanks to automatic start-stop system
• Emissions from hybrid system considerably lower than voluntary EEV standard
• MAN PURE DIESEL technology without additional service fluids ensures adherence to limit values at all times, even at low exhaust gas temperatures
• Demand-based, controlled and electrified auxiliary units provide a further fuel saving
• Durable and reliable high performance capacitors (Ultracaps) are maintenance-free and last as long as the vehicle
• Clear and easy to read efficiency display in MAN cockpit helps the driver to fully utilise the potential of the hybrid system
• 10% better air flow on roof compared with conventional CNG units provides optimal cooling for Ultracaps and improved cd factor
Hybrid bus
## Hybrid bus

<table>
<thead>
<tr>
<th>Technical data</th>
<th>Volvo Bus Hybrid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up-time</td>
<td>At least as high as diesel engine</td>
</tr>
<tr>
<td>Passenger capacity</td>
<td>Same as standard Volvo 7700</td>
</tr>
<tr>
<td>Preferable traffic type</td>
<td>City centre, City Commuter, Intercity</td>
</tr>
<tr>
<td>Power</td>
<td>Motor + Engine, High Torque at low speed</td>
</tr>
<tr>
<td></td>
<td>Electrical-only mode</td>
</tr>
<tr>
<td>Noise</td>
<td>Much lower than todays bus (-4 dB)</td>
</tr>
<tr>
<td></td>
<td>Silent take-off</td>
</tr>
<tr>
<td>Fuel consumption</td>
<td>City centre more than 30% decrease</td>
</tr>
<tr>
<td></td>
<td>Commuter more than 20% decrease</td>
</tr>
<tr>
<td>Emissions</td>
<td>50% Less NOx and Particulates</td>
</tr>
<tr>
<td>Pay-back time</td>
<td>4-6 years</td>
</tr>
</tbody>
</table>
Calculated from energy consumption data of Jonas Åkerman / KTH, Hybrid and BRT bus data from Volvo
Efficient modularity can create greater operational flexibility through a modular vehicle approach. Inside the vehicle, modularity means flexibility of the interior layout and rapid conversion from maxi capacity to maxi seating. Outside the bus, it involves high-capacity buses and “variable geometry” capacity. Achieving modularity will contribute to optimising operating costs through:

- reduction of driving costs during peak hours
- optimisation of capacity, consumption and frequency in relation with traffic patterns
- better organisation of transport networks with the addition or removal of trailers at the strategic terminals, depending on levels of passenger demand.
*Dedicated bus lanes
*Enclosed stations
*Signal priority technology (to keep lights green)
*More attractive and comfortable buses
Chinese bus that actually goes right over traffic. Cars go underneath it like a tunnel. It’s almost as if it’s a train riding on it’s own raised tracks. It can hold over 1000 passengers and travel up to 60km/h right over traffic. There’s some sort of alarm warning sign if a truck that’s too tall attempts to drive underneath it. The bus is articulated to allow it to easily turn around corners. It is tall enough to go over cars yet short enough to still fit under existing overpasses. Because it only requires minimal surface tracks around the outside of the road, it can be built and deployed in 1/3 the time of a true subway. And deployed it will be; in Beijing’s Mentougou district where the first 186km of track was built in 2010.
Huge progress has been made on bus and stations’ design. Efforts must continue especially to develop the pleasure of travelling by bus.
Design
Conclusions

Bus best choice to lower greenhouse gases. Bus use minor amounts of energy and fuel. Bus undergoes rapid development, hybrids and BRT.
Thank you