RTD Fact Sheet

Mini fleet of clean vehicles for PT	
Reference Measure	1.1 – Mini fleet of clean vehicles for PT
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Context and Purpose

Bologna local authorities have always shown great interest for alternative fuel/engines in order to improve the sustainability of the public transport fleet. Since 2002, thanks also to regional funds, the public transport company invested in natural gas (CNG) buses and infrastructures (in 2012 the company has 206 CNG buses and two quick filling stations located in bus depots. Furthermore four of the main public bus lines are currently trolley lines (53 trolley buses). About 400 diesel buses, almost 80% of the urban fleet, have been equipped with particulate filter (FAP) to reduce emissions.

The RTD activity of the Mimosa measure aimed to realize a study concerning the technological possibilities to develop “clean” buses comparing existing technological options and prospects.

The study permitted the identification of the the best technological solution to introduce low pollutant buses considering the scenario of Bologna and the results have been the input for the realization of the technical specifications for a call for tender for the supply of the vehicles.

Description of RTD Activity

The study aimed to identify the best technological solution to introduce low pollutant buses in Bologna scenario.

TPER realized the analysis for the development of a bus fleet with characteristics of environmental sustainability and reasonable costs. The study takes into account the state of the art and the market trend of buses, considering development and technological innovations concerning environmental sustainability.

The methodologies used to evaluate the different solutions were:

- ✓ life cycle assessment (LCA);
- ✓ life cycle cost (LCC);
- ✓ well to wheel (WTW).

“Life-cycle cost” (**LCC**), refers to the total cost of ownership over the life of an asset. Costs considered include the financial cost which is relatively simple to calculate and also the environmental and social costs which are more difficult to quantify and assign numerical values. Typical areas of expenditure which are included in calculating the whole-life cost include, planning, design, construction and acquisition, operations, maintenance, renewal and rehabilitation, depreciation and cost of finance and replacement or disposal. Whole-life cost analysis is often used for option evaluation when procuring new assets and for decision-making to minimise whole-life costs throughout the life of an asset. It is also applied to comparisons of actual costs for similar asset types and as feedback into future design and acquisition decisions. The primary benefit is that costs which occur after an asset has been constructed or acquired, such as maintenance, operation, disposal, become an important consideration in decision-making. Previously, the focus has been on the up-front capital costs of creation or acquisition, and organisations may have failed to take account of the longer-term costs of an asset.

A “life cycle assessment” (**LCA**, also known as life cycle analysis, ecobalance, and cradle-to-grave analysis) is a technique to assess each and every impact associated with all the stages of a process from-cradle-to-grave (i.e., from raw materials through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling). LCA’s can help avoid a narrow outlook on environmental, social and economic concerns. This is achieved by:

- Compiling an inventory of relevant energy and material inputs and environmental releases;
- Evaluating the potential impacts associated with identified inputs and releases;
- Interpreting the results to help you make a more informed decision.

The goal of LCA is to compare the full range of environmental and social damages assignable to products and services, to be able to choose the least burdensome one.

The term 'life cycle' refers to the notion that a fair, holistic assessment requires the assessment of raw material production, manufacture, distribution, use and disposal including all intervening transportation steps necessary or caused by the product's existence. The sum of all those steps – or phases – is the life cycle of the product.

The “**well to wheel**” (**WTW**) approach was particularly interesting: this method evaluates the whole energetic chain of bus engines starting from the fuel production arriving to the bus wheel.

It consists of two parts:

- “Well to tank” that means evaluation of energetic consumption to extract and transport the fuel to the bus tank;
- ”Tank to wheel” from the vehicle tank to the vehicle wheels.

Energy efficiency in addition to the emission levels is an important factor to determine the sustainability of the transport systems.

Several alternative fuels have been considered:

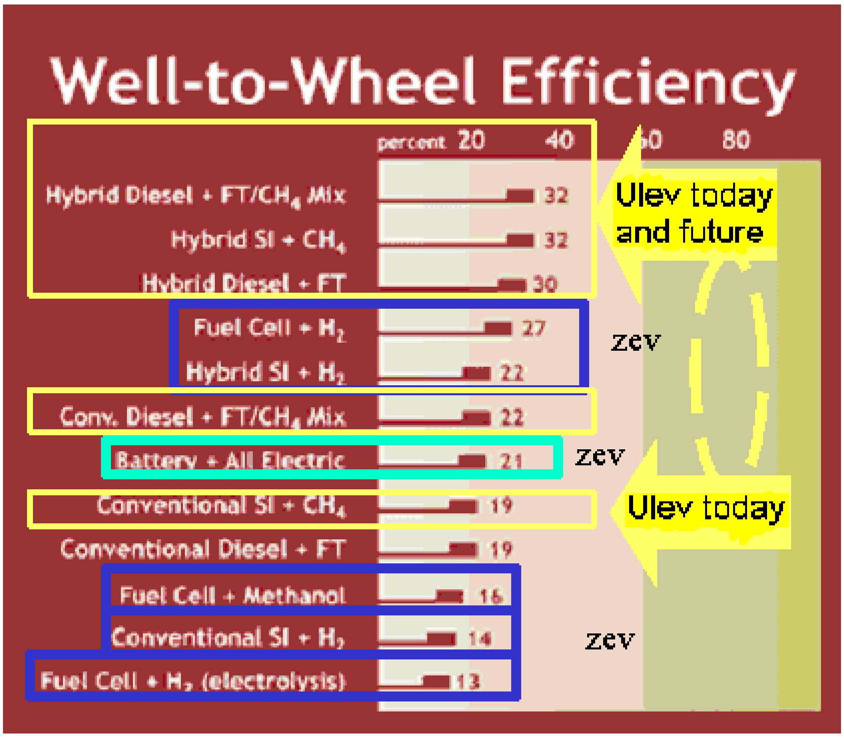
- hydrogen
- methanol
- electricity
- natural gas (CNG)

Another key aspects for the fuel choice is the logistics: for example the hydrogen at the moment hasn’t any structured logistics and this situation will probably continue for the next years.

Several traction system were considered in the study:

- traditional
- hybrid
- fuel cell
- electric

The energetic comparison using the well to wheel approach can be summarized by the following figure:



The figure show that hybrid vehicles are the best choice considering the well to wheel approach.

Hybrid vehicles reduce fuel consumption under certain circumstances, compared to otherwise similar conventional vehicles, primarily by using three mechanisms:

1. Reducing wasted energy during idle/low output, generally by turning the internal combustion engine off
2. Recapturing waste energy (i.e. regenerative braking)
3. Reducing the size and power of the internal combustion engine, and hence inefficiencies from under-utilization, by using the added power from the electric motor to compensate for the loss in peak power output from the smaller internal combustion engine.

Any combination of these three primary hybrid advantages may be used in different vehicles to realize different fuel usage, power, emissions, weight and cost profiles. The internal combustion engine in a hybrid vehicle can be smaller, lighter, and more efficient than the one in a conventional one, because the combustion engine can be sized for slightly above average power demand rather than peak power demand.

The power curve of electric motors is better suited to variable speeds and can provide substantially greater torque at low speeds compared with internal combustion engines.

Substantial use of the electric motor at idling and low speeds implies reduced noise emissions.

Following the study results, hybrid engine has been adopted for the development of the small fleet of vehicle in Bologna.

Outputs and Results

The study showed how hybrid vehicles are the best solution both for companies that already invested in alternative buses (trolley buses, natural gas buses) and reached the saturation point of infrastructures and for companies that have no possibilities to invest in infrastructures because hybrid technology is the only possibility to reduce energy consumption in the medium term.

Furthermore innovative hybrid buses that were adopted in Bologna are equipped with innovative super capacitors that replace conventional electric batteries. Compared to traditional hybrid vehicles, they offer a considerable reduction in fuel consumption through lower exhausted gas emissions. Maintenance costs are reduced, as they do not need periodical substitution of the conventional batteries.

Super capacitors can stand a significantly higher number of charge-discharge cycles and last longer than conventional batteries, making both the super capacitor and vehicle more environmentally friendly. Additionally, as super capacitors are not limited by low battery charge levels, these new buses make for a more reliable, constant and long serving bus service.

Resulting Decision-making

The results of the feasibility study have been the input for the realization of the technical specification for a call for tender for the supply of hybrid vehicles with innovative characteristics. The call for tender concerned the supply of 2 hybrid buses and was awarded in May 2011. The selected buses are equipped with innovative super capacitors that replace conventional electric batteries. Compared to traditional hybrid vehicles, they offer a considerable reduction in fuel consumption through lower exhausted gas emissions. Maintenance costs are reduced, as they do not need periodical substitution of the conventional batteries.

Lessons Learnt

Impact on the company organization: A company that wants to develop a "sustainable" bus fleet has to consider that sustainability has not only technological implications but has also cultural impact on the company organization. Before the purchase on the market of low environmental impact buses, the company has to improve its internal processes as concerns:

- personnel training
- adaptation of maintenance process
- adaptation/realization of infrastructure
- logistics for the supply of innovative fuels

This cultural impact explains why the introduction of new sustainable vehicles is possible only in the medium-long period. Without a "cultural" approach the company will face too high costs of operation and low service level of new buses.

Choose a «mature» technology: The innovative technology chosen has demonstrated its validity and its correspondence to the needs of a transport company. For a transport company it's important to improve the bus fleet with innovative buses with low environmental impact; at the same time it's fundamental that the innovative technology chosen is a "mature" technology that allows to have buses in real service in the city every day and not only prototypes parked in a depot.

Cost-effectiveness

Innovative hybrid vehicles equipped with super capacitors have an initial purchase cost slightly higher than traditional ones.

Effectiveness balances this initial extra-cost: no investment in infrastructures are needed, the fuel consumption measured in real service demonstrated a sensible saving and also emission levels are lower. Super capacitors reduce the operation costs because they do not need to be replaced as requested for traditional batteries every three years and they are not limited by low battery charge levels so they guarantee a more reliable, constant and long bus service.

Dissemination and Exploitation

The hybrid bus is a simple solution that can be adopted to develop an environmental friendly bus fleet: hybrid technology guarantees low emission levels and the introduction of this vehicles does not imply infrastructural investment.

We think that the purchase investment plan of TPER for the next year will foresee the introduction of further hybrid vehicles.

We also think that this solution can be easily adopted from other transport companies that want to improve the environmental sustainability of their fleets.