



# Key Messages from AMF Research

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Annex 53-1

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## Sustainable bus system

**Operating Agent: Ministry of Transport and Telecommunications of Chile and Centre Mario Molina, Chile**  
**Partners: Canada, Finland, Sweden**

### Major Conclusion

Affordable, clean and energy efficient public transport systems based on buses require adaptation to local conditions. This is especially important in emerging economies with significantly sized bus fleets and severe driving conditions, as many test procedures are developed for European or North American conditions which might differ from the real driving conditions in for example Latin America. In this Annex, a special test cycle and test methodology representing the conditions for urban buses in Santiago de Chile was developed. The observed energy consumption of the buses was greater in the cycles adopted for the actual conditions in Santiago de Chile compared to other cycles not representative to the real local driving conditions. These differences may vary depending on the technology used, e.g. diesel, gas, electric.

Furthermore, it was determined that the test cycle alone is not enough for ensuring affordable, clean and energy efficient buses in emerging economies. The procedure should be complemented with a methodology for establishing requirements for clean and energy-efficient buses to be used in the tendering process for public transport operators in developing regions. The methodology should include guidance and recommendations to control and follow up the buses in service, especially in the case of Euro VI, Inspection and Maintenance (I&M), periodic measurement of emissions and fuel/energy consumption, and using proper fuel and lubricant qualities, all this to ensure proper in-use performance.

### Background

Some of the biggest cities in Latin America are facing the renewal of their bus fleets, both due to outdated performance and age. It is essential that, at this juncture, energy-efficient, low-polluting, soot-free buses are introduced into their bus transport systems. In this context, advanced technologies require an appropriate characterization of the advantages of clean and energy-efficient buses in terms of emissions, operational costs, and fuel economy. These characteristics vary, however, depending on local operating conditions, emission regulations, fuel quality, and type of service the buses provide. Verified performance data is needed, as well as test and assessment methodologies that reflect local needs and conditions.

## Research Protocol

The “Sustainable Bus Systems” project involved four components:

- 1) the design of a driving cycle and test procedures which represent the operating conditions of buses in the Santiago public transportation system,
- 2) the development of a laboratory-testing program for buses with advanced technologies in Santiago and in Europe,
- 3) the testing of eight buses using the Santiago Bus Cycle, and the simulation of the behaviour of the different bus technologies tested in VTT's laboratories in Finland, using the Autonomie vehicle modelling software, and
- 4) the preparation of recommendations both for the use of the Santiago bus cycle, and for the test procedures which Ministry of Transport and Telecommunications of Chile carries out during the evaluation and selection of bus technologies that will enter the Santiago public transport system's fleet.

The Ministry of Transport and Telecommunications officially adopted the Santiago Bus Cycle and procedures in July 2018. Every new bus model must be tested under these conditions in the homologation process and the information is to be published on the website of the certification center (3CV) belonging to the Ministry.

## Key Findings

Key findings from the project can be summarized as follows:

- An evaluation of the operational conditions of urban bus systems in developing countries must be undertaken as they may be different to those used internationally to evaluate buses.
- The emissions of a Euro VI bus measured with the Santiago Bus Cycle are different to the results seen with the conventional cycles, specially in NO<sub>x</sub>. However, emissions from the Euro VI bus were still very low in comparison with Euro III buses.
- The energy consumption is higher in the Santiago bus cycle than in the Braunschweig cycle; up to 60% higher for the same Euro VI diesel bus.
- Battery electric buses consume less than a quarter of the energy that a diesel bus requires per kilometer under the Santiago bus cycle conditions.
- This methodology will allow that the fleet renewal with Euro VI buses and the progressive introduction of electric buses, will result in the highest possible reductions in energy consumption, operating cost and emissions
- The Annex was a key part of the work done by Ministry of Transport and Telecommunications and Centro Mario Molina Chile, and the Ministry received the Climate and Clean Air Award for Enabling Policy in 2018 for this.