
**Smart community infrastructures —
Smart transportation using battery-
powered buses for passenger services**

*Infrastructures urbaines intelligentes — Transport intelligent
utilisant des bus alimentés par des batteries pour le transport de
voyageurs*

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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Introduction

City centres, often small areas, are frequently congested with internal-combustion-engine-driven vehicles. This creates significant city issues, including air pollution from greenhouse gases (GHGs) and irritation to citizens from noise and vibration. The number of internal-combustion-engine-driven private vehicles nowadays is small. Heavy trucks, which are commonly driven by internal combustion engines, are not allowed in city centres. Thus, the main source of such air pollution and environmental irritation is now commercial vehicles, i.e. buses equipped with internal combustion engines (see [Annex A](#)). Fuel energy is more efficiently converted to driving forces by motors consuming electric power generated from fuel than by engines directly burning fuel. Therefore, motor-driven or battery-powered buses are suitable options for transportation vehicles.

Bus transportation systems offer convenient and casual transport for citizens in all cities as they can operate in narrow streets in accordance with passenger flow changes in a city and require minimum facilities for bus stops. However, although bus journeys are popular among citizens, the ride comfort is not always of a high quality due to sudden stops to avoid collisions or traffic accidents, and irritating jerky movements caused by the traction mechanism in the internal combustion engine driving systems. Such behaviour can give passengers motion sickness or discomfort or even lead to injuries.

At the same time as promoting modal shifts from conventional to alternative systems, service performance and quality should be maintained or improved, in particular regarding low environmental impact, safe and steady operation and passenger ride comfort. Battery-powered bus transportation systems are now commonly used for short-distance transportation and contribute to solving the issues mentioned previously in a number of cities across the world (see [Annex B](#)).

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Smart community infrastructures — Smart transportation using battery-powered buses for passenger services

1 Scope

This document specifies a procedure for the introduction of smart transportation to city centres by means of battery-powered buses. This service contributes to a clean atmosphere and a relatively quiet environment while offering services that provide safe and comfortable rides for citizens.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1

battery-powered bus

bus run by electric power that is provided only with onboard rechargeable batteries

3.2

rechargeable battery

battery which can be recharged within an allowable waiting time for the next operation

Note 1 to entry: Batteries which do not cause any change to currently organized bus service operations are to be used in smart transportation. In this case, battery recharging should be completed in the same bus operation schedule as already adopted so that buses currently in service can simply and successfully be replaced with battery-powered buses.

3.3

recharging

putting an electrical charge back into battery-powered buses

Note 1 to entry: Recharging can be done by directly applying voltage to batteries onboard or, if the work can be completed in the current allowable waiting time, by swapping discharged and fully charged batteries. Wireless charging while battery-powered buses are running could be another way to recharge batteries onboard, if this procedure does not disturb current bus operation.

4 General

Battery-powered buses are driven with traction motors run by electricity. Motors can indirectly convert fuel energy into driving forces extremely efficiently by consuming electricity that is generated from fuel by a power plant in a normal way. Thus, motor traction saves energy compared with engine traction, which burns fuel directly. In addition, battery-powered buses emit no pollutants or GHGs into the atmosphere (see Annex C, which shows a typical application of battery-powered buses in a city). Furthermore, traction motors enable buses to run quietly with little irritating vibration. This enables battery-powered buses to maintain a good environment for those living near bus routes, while

providing onboard passengers with good ride comfort through continuously varying acceleration. This cannot be accomplished by internal combustion engine systems, which create uncomfortable jolting during gear changes.

One of the goals of smart transportation is not to disturb current service performance and quality, but rather improve it further compared with conventional services. No changes should be made to current operating systems, including working schedules, dispatching and facilities related to internal-combustion-engine-driven bus operations, both during and after the introduction of smart transportation.

Smart transportation aims to solve the issues of air pollution from GHGs and irritation to citizens from noise and vibration in cities and should also contribute to the further development of cities by satisfying the purposes designated in ISO 37101:2016^[2].

5 Operation of smart transportation using battery-powered buses

5.1 General

Smart transportation in the form of battery-powered bus operation solves specific city issues as mentioned in [Clause 4](#) by retaining the same operation, services and facilities as those already in place for internal-combustion-engine-driven bus operation when some of the buses are replaced with battery-powered buses. When all internal-combustion-engine-driven buses in service are replaced, or when battery-powered buses are newly installed in an area where no bus operation has been in service, it is not necessary to follow the requirements given in [5.2.1](#) to [5.2.4](#), [5.2.7](#) and [5.2.8](#). Battery-powered buses shall, however, be operated according to the requirements specified in [5.2.5](#), [5.2.6](#) and [5.2.9](#).

5.2 Minimum requirements to organize smart transportation

5.2.1 Recharging

Recharging work shall be completed within the same working schedules as those applied to current internal-combustion-engine-driven bus operation in the replacement with battery-powered buses. Allocate recharging work to refuelling work time or stand-by time for the next turn-back operation at a terminal. Electrical capacity shall be capable of supporting battery-powered bus recharging. Cities can implement renewable energy as one of the options for recharging (see Table B.2).

5.2.2 Scheduling/dispatching

Operation scheduling and bus dispatching shall be organized to permit current internal-combustion-engine-driven bus operation even when it is partly or entirely replaced with battery-powered bus operation.

5.2.3 Maintenance work

To the maximum extent practical, all maintenance work, such as cleaning, inspecting and overhauling bus vehicles, shall be completed in the same working schedules as for current maintenance work for internal-combustion-engine-driven buses, for replacement with battery-powered buses.

5.2.4 Passenger services

All passenger services, including fare payment, in-/out-coming, coach accommodations and passenger capacity, shall be neither inconvenient nor poorer than those currently organized when replaced with battery-powered buses.

5.2.5 Safety and ride comfort

Battery-powered buses shall provide safer and more comfortable rides than internal-combustion-engine-driven buses, especially when the bus suddenly accelerates or brakes. To measure the improvement, use appropriate metrics already published.

5.2.6 Weather and climate conditions

Battery-powered buses shall be operated under the same weather and climate conditions in which internal-combustion-engine-driven buses are operated.

5.2.7 Driving conditions

Battery-powered buses shall be operated under the same bus-driving conditions as those with internal-combustion-engine-driven buses.

5.2.8 Driving skills/performance

No specific skills or experience shall be required to drive battery-powered buses, meaning few differences in driving performance.

NOTE Emergency response procedures for battery-powered buses can differ from those of internal-combustion-engine-driven buses.

5.2.9 Energy saving

The operation schedule and running performance of battery-powered buses shall be optimized and controlled, respectively, in order to save battery energy consumption.

6 Maintenance of the quality of smart transportation using battery-powered buses

6.1 General

To maintain the intended performance of smart transportation, and to confirm its effectiveness, periodically observe the parameters in [6.2](#).

6.2 Parameters to be observed

The parameters for comparing smart transportation performance are shown below. Use appropriate units for observation:

- traffic flow from/to the target area;
- traffic share of battery-powered bus transportation systems in the target city/area;
- degree of air pollution, including GHG emission, noise and vibration;
- number of safety incidents involving onboard passengers.

6.3 Modification of smart transportation

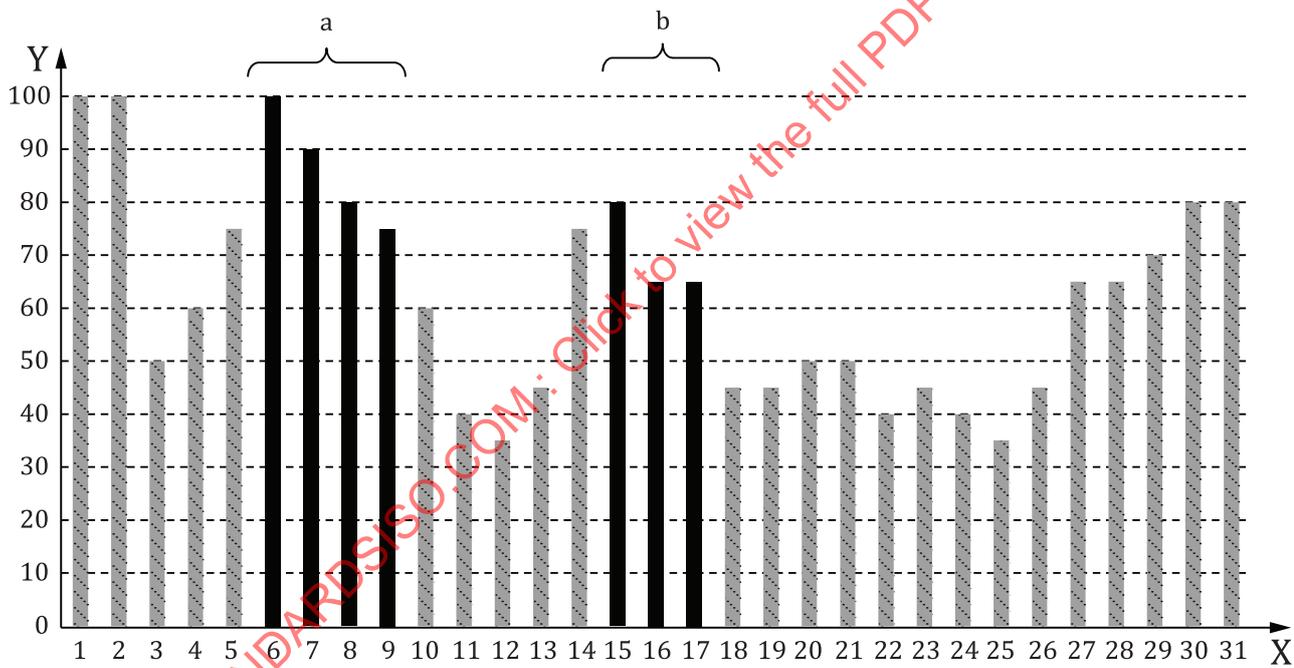
When no change in the value of the parameters designated in [6.2](#) is found, change the conditions of smart transportation in [5.2](#). To correct the transportation conditions, confirm anything unexpected at planning or irregular due to specific local situations taking place in the area where smart transportation was installed. Modify the current conditions of the smart transportation system operated by making sure that irregular conditions are acceptable.

Annex A (informative)

Trials given by Paris City in December 2016 to suppress air pollution by inviting citizens using internal-combustion-engine-driven vehicles to electrically-operated transportation services

A.1 Paris trials to reduce air pollution by positively using electric transportation

To observe changes in air pollution in the Greater Paris Area, France, Paris City and 22 communities surrounding the city restricted private use of internal-combustion-engine-driven vehicles by offering free public transportation (mostly electrically-operated trains and buses) to citizens in the area. Trials were carried out twice in December 2016. During the trials, citizens drastically shifted from internal-combustion-engine-driven vehicles to electric transportation. As a result, air pollution in Paris was reduced during and after the trials, as shown in [Figure A.1](#).



- Key**
- X date, December 2016
 - Y Citeair index
 - a First trial.
 - b Second trial.

NOTE Air pollution is indicated with a Citeair index or a traffic and air pollution indicator as a mix index.

Figure A.1 — Suppression in air pollution in Paris during trials of the shift from internal-combustion-engine-driven vehicles to electric transportation

Annex B (informative)

Example of cities and countries where battery-powered buses are operated

Battery-powered buses are in service in over 300 cities in 19 countries as of July 2019. China has introduced such buses in 275 cities, including Beijing, Changsha, Chongqing, Dalian, Fuzhou, Hangzhou, Hefei, Nanjing, Nantong, Qingdao, Shanghai, Shenzhen, Taiyuan, Tianjing, Wuxi, Xiamen and Xian. Other cities and areas which have introduced battery-powered buses are listed in [Table B.1](#). Battery-powered buses which use renewable energy when recharging are in service in Uganda and Uruguay.

Table B.1 — Cities and areas using battery-powered buses

Aachen (Germany)	Lyon (France)
Aomori (Japan)	Manali (India)
Berlin (Germany)	Mecklenburg-Vorpommern (Germany)
Bonn (Germany)	Milan (Italy)
Botosani (Romania)	Milton Keynes (UK)
Braunschweig (Germany)	Miyako (Japan)
Bremen (Germany)	Munich (Germany)
Busan (Korea)	Nante (France)
California (US)	Neumarkt (Germany)
Chennai (India)	New Taipei City (Taiwan)
Dehradun (India)	Nottingham (UK)
Delhi (India)	Oslo (Norway)
Dresden (Germany)	Paris (France)
Frankfurt (Germany)	Pinneberg (Germany)
Geneva (Switzerland)	Poznan (Portugal)
Gumi (Korea)	Putrajaya (Malaysia)
Hamburg (Germany)	Rendsburg (Germany)
Hamura (Japan)	Roma (Italy)
Hyderabad (India)	Roseburg (Germany)
Ise (Japan)	Rotterdam (Netherlands)
Jaworzno (Poland)	Sabarimala (India)
Jeju (Korea)	Satsuma-Sendai (Japan)
Kawasaki (Japan)	Schleswig-Holstein (Germany)
Kesen-numa (Japan)	Sejong (Korea)
Kita-Kyusyu (Japan)	Seoul (Korea)
Kyoto (Japan)	Tokyo (Japan)
La Rochelle (France)	Torino (Italy)
London (UK)	Umeå (Sweden)
Lucknow (India)	Vienna (Austria)

Annex C (informative)

A typical city aiming at low-carbon transportation^[5]

Putrajaya in Malaysia has been built on virgin land with a planned population of 350 000 in an area of 50 km² next to a lake located between Kuala Lumpur, the capital of the country, and Kuala Lumpur International Airport. The city aims to achieve a carbon emission reduction of 60 % by 2020 based on the commitment at COP15, held in Copenhagen, Demark, in 2009. To establish low-carbon transportation systems in the city, buses are going to be battery-powered. [Table C.1](#) indicates the contribution of low-carbon transportation in the form of battery-powered buses to achieving the carbon emission goal. The bus transportation system introduced has quick recharging facilities, as shown in [Figure C.1](#), to successfully dispatch a minimum number of buses. The bus network covers indispensable facilities for citizens such as residential areas, shopping malls, hospitals, schools, business areas, railroad stations, green parks and national/local government. The city is still a newly developing area but functions as a compact city as defined in ISO 37157:2018, 3.1^[4] in some parts.

Table C.1 — Actions for carbon emission reduction in Putrajaya City

Action number	Action title	CO ₂ emission reduction 1 000 kg _{CO2}	Contribution in total reduction %
1	Integrated city planning and management	312	15,6
2	Low-carbon transportation ^a	582	29,0
3	Cutting-edge sustainable buildings	666	33,2
4	Low-carbon lifestyle	71	3,5
5	More and more renewable energy	50	2,5
6	The green lung of Putrajaya	35	1,7
7	Cooler urban structure and building	64	3,2
8	Community and individual actions to reduce urban temperature		
9	Use less consume less	3	0,1
10	Think before you throw	134	6,7
11	Integrated waste treatment	88	4,4
12 ^b	Green incentives and capacity building	—	—
Total of PGC2025 actions		2 005	100
Others ^c		400	—
Total		2 405	—

a Introduction of battery-powered buses as low-carbon transportation that effectively works to reduce carbon emissions.
b Action 12 does not have any direct emission reduction.
c Includes contributions from freight transport (2,8 %) and central power generation (13,8 %).