BS ISO 37161:2020

BSI Standards Publication

Smart community infrastructures — Guidance on smart transportation for energy saving in transportation services

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National foreword

This British Standard is the UK implementation of ISO 37161:2020.

The UK participation in its preparation was entrusted to Technical Committee SDS/2, Smart and sustainable cities and communities.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Published by BSI Standards Limited 2020

ISBN 978 0 539 01192 0

ICS 03.220.01; 13.020.20

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 March 2020.

Amendments/corrigenda issued since publication

Date	Text affected

BS ISO 37161:2020

INTERNATIONAL STANDARD

ISO 37161

First edition
2020-02-28

Smart community infrastructures — Guidance on smart transportation for energy saving in transportation services

Infrastructures urbaines intelligentes — Recommandations sur le transport intelligent pour les économies d'énergie dans les services de transport

Reference number
ISO 37161:2020(E)

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 268, *Sustainable cities and communities*, Subcommittee SC 1, *Smart community infrastructures*

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Energy saving is one of the typical and measurable issues to be addressed in every city in the world. Energy is consumed whenever citizens move within and between cities by using transportation services for their daily living and business activities. This energy consumption volume is higher than that of other city functions such as water and ICT systems, as transportation systems convey a large number of passengers and delivery items or freight – which can sometimes be enormous – resulting in large, heavy vehicles travelling at high speed. Smart transportation is not necessarily an infrastructure but definitely a solution to existing or future city issues, as explained in ISO 37154. Transportation operation itself will be targeted and expected to produce drastic energy savings, but there is also large energy consumption and waste in transport procedures besides operation. Smart transportation for energy saving is, therefore, an important factor in enhancing city performance, quality and potential.

The principle of smart transportation for energy saving depends not only on transportation modes but also on methods of traction for running transportation vehicles, because energy is consumed mainly when driving vehicles. In addition to vehicle operation, energy is used to support dispatch operations and organize entire transportation systems. Therefore, to successfully reduce energy consumption, the entire structure of transportation systems needs to be studied. This would involve identifying where energy can be saved in the system and the people who can make arrangements for or directly contribute to energy saving. Different energy-saving options are available. By combing these methods, energy can be more effectively saved in transportation which consists of a variety of technical and service fields supporting the system.

This document describes what smart transportation for energy saving targets and how it works in transportation systems, according to the general guidelines on smart transportation of ISO 37154, which fully explain the structures, aspects and features of transportation operation, services and technical/business content from the different viewpoints of those who use, plan and provide or operate transportation systems. This document also identifies specific ways to save energy consumed in transportation operation and services.

In the development of this document, ISO Guide 82 has been taken into account in addressing sustainability issues.

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INTERNATIONAL STANDARD ISO 37161:2020

Smart community infrastructures — Guidance on smart transportation for energy saving in transportation services

1 Scope

This document provides guidance on reducing the energy consumed by transportation for passengers, delivery items, freight and postal item services in cities and city zones.

This document does not designate specific procedures to save energy but suggests energy-saving options to be adopted in transportation systems normally organized in different locations, on different scales and for different purposes.

NOTE Some typical energy-saving options are listed in 6.2.2.

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
transportation energy
energy consumed in transportation operations and services

3.2
city zone
area that comprises a single core city or more than one core city connected or related for/with business, economic and political activities

Note 1 to entry: A city zone comprising more than one core city is called a megalopolis. Some well-known examples are BosWash (USA), Blue Banana (Europe) and the Tokaido Megalopolis (Japan).

4 Fundamentals

4.1 Basic ideas and goals

As stated in ISO 37154, any smart transportation has basic ideas and goals. They are considered according to the criteria listed below:

— to improve the status of a city;

— to lower environmental load;

— to realize transportation facilities based on concrete planning (e.g. payable budget scales, environmental harmonization);

— to improve communication to the public about all aspects of transportation services.

These objectives can be achieved by ensuring the transportation system's performance and ability to:

— convey passengers, delivery items and freight
  — safely;
  — when they are in a large lot;
  — at one time;
  — on time;
  — as planned;
  — at a low cost;
— provide dense networks for transport;
— provide frequent services for transport;
— provide successful and easy connection for transport between different transportation systems or modes;
— control total energy saving/consumption for transportation;
— lower environmental load without reducing the service quality of transport operations.

An integrated urban transportation plan enables:

— the transport of people and goods safely, reliably, efficiently and economically;
— the provision of networks appropriate for transportation needs, especially investing in and improving existing infrastructures;
— the creation of frequent services for transport;
— the provision of efficient connections for transport between different transportation systems or modes;
— the lowering of total energy usage/consumption for transportation;
— the lowering of environmental impact without degradation in service quality of transport operation;
— the economically stable operation of transportation with fares/fees reasonable or affordable for local citizens.

5 Targets of smart transportation for energy saving

5.1 General

As discussed in 4.2, energy saving targets should be carefully determined when introducing smart transportation in transportation system structures. ISO 37154 describes these structures according to the transportation modes used. Each transportation mode has specific transportation technical and business contents that provide characteristic transportation services to customers. Thus, smart transportation for energy saving targets all or part of the structures featured by transportation services, transportation technical and business contents and transportation modes.

5.2 Targets of smart transportation

5.2.1 Target transportation modes

Smart transportation for energy saving targets the following transportation modes, which are also the transportation modes of smart transportation in the general meaning defined in ISO 37154:2017, 3.7.

— rail;

— commuter buses, bus rapid transit and intercity buses;

— trucks;

— ferries;

— pipelines;

— air vehicles;

— walking;

— bicycles;

— motorbikes;

— automobiles;

— boats;

— transportation devices assisting passengers, delivery of items and freight for moving in stations and terminals (e.g. elevators, escalators, moving walkways, conveyors);

— vehicles or systems and their additional instruments assisting mobility-impaired persons (e.g. scooters, Segways).

5.2.2 Target technical and business contents of transportation

5.2.2.1 General

Any transportation mode has specific technical and business contents. Smart transportation for energy saving can be introduced in transportation organized for public or private purposes in cities and city zones by targeting the technical and business contents dependent on the transportation mode targeted.

5.2.2.2 Public transportation

Public transportation is organized for specific purposes, or what (e.g. people, items) the transportation conveys and from where to where. Smart transportation targets the technical and business contents of the transportation mode used in public transportation.

a) Rail mode

— passengers, delivery of items and freight services (e.g. customer services at stations and freight yards, refrigeration for delivery items and freight);

— accommodation preparation and management (e.g. water supply, cleaning, air-conditioning, coach brightness adjustment);

— train operations (e.g. scheduling, dispatching, refuelling, train crew);

— rolling stock (e.g. accommodation, maintenance, refrigeration for delivery of items and freight);

— power/signalling;

- communication for train operations;
- facilities (e.g. stations, tracks, civil engineering structures);
- safety (e.g. surveillance);
- environment (e.g. noise, vibration, pollutants and greenhouse gas emission, sunlight);
- information availability (e.g. real-time information provision to passengers and senders/recipients on service frequency, routing, destinations and cost).

b) Bus/truck mode

- passengers, delivery of items and freight services (e.g. customer services at bus stations and delivery offices, refrigeration for delivery items and freight);
- bus and truck operations (e.g. scheduling, dispatching, drivers and conductors);
- refuelling/power charging;
- signalling and bus/truck tracking systems;
- communication for bus and truck operations;
- vehicles (e.g. accommodation, maintenance, refrigeration for delivery of items and freight);
- facilities (e.g. bus stations, freight yards, taxi stands, bus and truck lanes on public roads, bus tracks, civil engineering structures for bus and truck operations);
- information availability (e.g. real-time information provision to passengers and senders/recipients on service frequency, routing, destinations and cost).

c) Ferry mode

- passengers, delivery of items and freight services (e.g. customer services at ports, refrigeration for delivery items and freight);
- ferry operations (e.g. scheduling, dispatching, crew);
- refuelling and power charging;
- signalling;
- communication for ferry operations;
- vessels (e.g. accommodation, maintenance, refrigeration for delivery of items and freight);
- facilities (e.g. ports, ferry terminals, civil engineering structures for ferry operation);
- information availability (e.g. real-time information provision to passengers and senders/recipients on service frequency, routing, destinations and cost).

d) Air vehicle mode

- passengers, delivery of items and freight services (e.g. customer services at airports, refrigeration for delivery of items and freight);
- refuelling and power charging;
- air vehicle operations (e.g. scheduling, dispatching, crew);
- aircraft (e.g. pilotless aircraft);
- facilities (e.g. airports, civil engineering structures for aircraft operation);

— information availability (e.g. real-time information provision to passengers and senders/recipients on service frequency, routing, destinations and cost).

5.2.2.3 Private transportation

For private transportation, smart transportation targets the services provided to the owners, drivers or operators of the transportation by the following responsible governmental or government-related organizations or manufacturers:

— road administrators (e.g. traffic surveillance, road maintenance, green spaces or complete streets dedicated for walking and bicycles, streetlights, lighting for signboards, toll collection);

— transportation authorities (e.g. vehicle-sharing services including bicycles, motorbikes and automobiles);

— channel administrators (e.g. lighthouses, navigation aids);

— air-traffic authorities (e.g. airway beacons);

— police departments (e.g. traffic lights);

— fire departments;

— vehicle, boat and air vehicle manufacturers.

5.2.2.4 Public transportation for personal use

Smart transportation also targets the following transportation for personal use:

— rental vehicles (e.g. bicycles, motorbikes, automobiles, batteries and recharging devices for the vehicles).

5.2.3 Target transportation services

5.2.3.1 General

Smart transportation for energy saving targets the transportation services listed in the following subclauses, which are provided by transportation's technical and business contents.

5.2.3.2 Public transportation

a) Passenger services

— train, bus, ferry and air vehicle operations;

— safety for driving;

— weather forecast and information;

— communication during emergencies;

— travel planning;

— easy access to stations, ferry terminals and airports (e.g. pathways with roofs, arrangements for access to connect stations, bus stops, ferry terminals and airports, introduction of passengers);

— ticketing;

— ticket inspection (e.g. at stations, in coaches);

— fare/fee collection;

— connections and changing;

— inter-modal connections (e.g. rail and buses or trucks, rail and ferries, buses or trucks and ferries);

— connecting operations, including run-through vehicle operations (e.g. between different rail carriers, between sections with different-gauge tracks);

— information provision and indication (e.g. announcements in stations and coaches, multiple languages, frequency, timing, indication of operation and connection conditions);

— control of passenger flows and goods delivery routes in stations, ferry terminals and airports;

— assistance to the disabled, the elderly and those with physical impairments;

— food business (e.g. cafeterias, restaurants, dining cars, minibars on trains);

— shop operations;

— advertisements;

— internet connection;

— convenient location of stations, bus stops, ferry terminals and airports in a city;

— appropriate distances between stations and bus stops;

— business introduced into transportation facilities other than transportation services (e.g. nurseries, polling places);

— coach accommodation (e.g. pass, seat and instrument arrangements/furnishings, service equipment);

— delay minimization;

— optimization of the passenger capacity of coaches or train sets, buses, ferries and air vehicles;

— electronic fare/fee payment (e.g. through banks, digital or QR-code payment);

— variety of choices of travelling means;

— arrangements at time of emergency (e.g. providing detours by means of other carriers or transportation modes);

— emergency measures (e.g. fire apparatus, rescue vehicles, firefighters, ambulances, escape routes, preparation for terrorist attacks, natural disasters and traffic accidents);

— fare adjustment for accidents (e.g. ticket refund, free change of tickets, extension of ticket validity period);

— fare selection depending on a variety of customer demands and trends;

— flat-rate fare in a specific zone;

— freight (fare) pool systems;

— affordable fares.

b) Delivery of item and freight services

— train, bus, truck, ferry and air vehicle operations;

— safety in driving;

— weather forecast and information;

— communication during emergencies;

— emergency measures (e.g. fire apparatus, rescue vehicles, firefighters, ambulances, escape routes, preparation for terrorist attacks, natural disasters and traffic accidents);

— shipping and receiving planning;

— pick-up and delivery services;

— storage services;

— delivery of items and freight tracking (e.g. registering at pick-up, shipping and delivery);

— packing and unpacking services;

— safe handling of fragile or flammable items (e.g. item packing with transparent materials for easy recognition of contents);

— time and date appointment for pick-up and delivery;

— electronic fare payment (e.g. through banks, digital or QR-code payment);

— pick-up and delivery services in a building or specific area;

— door-to-door pick-up and delivery services using containers in cities.

5.2.3.3 Private transportation

a) Common vehicles

— safety in driving;

— control of private transportation;

— comfortable road conditions (e.g. line shapes, visibility, pavement);

— traffic information (e.g. congestion, traffic control, road maintenance work);

— service information (e.g. energy station and shop location, toll routes);

— information on connections for other transportation (e.g. train, bus and ferry timetables);

— weather forecast and information;

— information signs;

— emergency calls;

— emergency measures (e.g. fire apparatus, rescue vehicles, firefighters, ambulances, escape routes, preparation for terrorist attacks, natural disasters and traffic accidents);

— energy stations [e.g. gas, liquid propane gas (LPG), electric power, hydrogen];

— parking lots;

— vehicle sharing;

— rental vehicles (e.g. bicycles, motorbikes, automobiles);

— dedicated bicycle lanes (e.g. bicycles, motorbikes, automobiles);

— toll collection.

b) Pooling vehicles

— rental vehicles (e.g. bicycles, motorbikes, automobiles, batteries and recharging devices for the vehicles).

6 Introduction of smart transportation for energy saving

6.1 Introduction of smart transportation

6.1.1 General

Smart transportation for energy saving can be introduced in operations arranged by the same (e.g. rail to rail) and different (e.g. rail to bus) transportation modes and on interfaces between public and private transportation.

6.1.2 Services in the same transportation mode

In the same transportation mode, smart transportation can be introduced in run-through operation, besides an operation by a single carrier or a rail track/road/airway owner or manager:

— run-through train operations [e.g. conventional rail and metro or light rail transit (LRT), electrified and non-electrified sections];

— run-through bus operations (e.g. different bus carriers, different licensed bus routes/territories);

— operation with good connection in time and place between different carriers (e.g. connection between private and government-operated rail carriers and between different bus carriers);

— ticketing for travel to other carriers;

— arrangements for shipping to other carriers;

— long-distance and high-speed transportation (e.g. intercity high-speed trains, magnetic levitation trains);

— strategic commuter services (e.g. direct connection of key stations downtown and in the suburbs);

— large network transportation systems (e.g. multiple inter-rail carrier through train operation to bring people from a broad area to specific locations).

6.1.3 Inter-modal services

Among different transportation modes, smart transportation can be introduced in inter-modal operations:

— inter-modal operations or operation with good connection in time and place between/among different transportation modes (e.g. connection of rail and buses, train operations to send/receive passengers, delivery of items and freight to/from bus and ferry services);

— ticketing for travel by using inter-modal transport;

— ticketing for travel to destinations on other carriers' lines or on run-through operation lines by other carriers;

— communication with other carriers regarding travel for the disabled, elderly and those with physical impairments;

— arrangements for shipping to different-mode carriers (e.g. from rail to trucks and ferries);

— reshipment of delivery items and freight at junctions.

6.1.4 Services involving interface between public and private transportation

Smart transportation can be introduced to provide customers with easy changes between public and private transportation:

— temporary stops for private vehicles;

— assistance to the disabled, elderly and those with physical impairments with changes between public and private transportation;

— parking lots for private vehicles including bicycles, motorbikes and automobiles;

— return delivery services for private vehicles including bicycles and motorbikes;

— onboard transport services for private vehicles including bicycles, motorbikes and automobiles;

— private vehicle shipment;

— safe access for customers walking to/from transportation facilities (e.g. skywalks, pedways, sidewalks);

— easy access for customers walking to/from transportation facilities (e.g. elevators, escalators, moving walkways, sidewalks with a roof or protectors);

— convenient access for customers walking to/from transportation facilities including kiosks, convenience shops, travel item shops, shoe and umbrella shops, first-aid stations, clinics, post offices, posts, stationary shops, internet access areas, fast-food shops, restaurants, public phones and ATMs.

6.2 Selection of energy-saving options

6.2.1 General

To save transportation energy, as mentioned in 4.2, the target section/line/area where smart transportation for energy saving is introduced depends on the situation or goals of the city or city zone. The geographical extent of smart transportation introduced will range from a single carrier or independent service line/section to a local service area or a large transportation network. The extent of the planned energy saving will depend on how many energy-saving options are applied.

6.2.2 Energy-saving options

The following energy-saving options can be applied by considering, for example, target transportation modes, technical/business contents and services. More options will be available when the technologies are improved or developed and confirmed for practical usefulness.

— optimizing transportation schedules (e.g. vehicle speed profile designing and modification for on-time and/or energy-saving operation);

NOTE A typical example of options is shown in Figure A.1 in Annex A, which is performed by optimizing rail service schedules.

— arranging vehicle dispatch (e.g. rolling stock scheduling and allocation);

— evaluating driver skill in driving vehicles (e.g. bus and truck operation).

6.2.3 Criteria and parameters to be considered in the selection of energy-saving options

The following criteria should be taken into consideration when selecting appropriate energy-saving options. Normally, the larger the target section/line/area where smart transportation for energy saving is introduced, the higher the cost of introduction. The wider the energy saving planned or expected, the higher the cost of introduction and the more complicated the control of the smart transportation

system. In contrast, the more extensive the introduction of smart transportation, the more effective the energy saving.

— budget scale;

— energy saving scale;

— allowable preparation term to start energy saving;

— organizers of smart transportation for energy saving (e.g. governors, transportation carriers);

— track/traffic capacities where smart transportation is introduced;

— power capacities where smart transportation is introduced, if the service line/section is electrified;

— rolling stock performance where smart transportation is introduced;

— service line planning where smart transportation is introduced.

6.3 Adoption of energy-saving options

When only one energy-saving option is applied, it is simply adopted in the targeted single carriers, independent service lines, local transportation service areas and/or large transportation networks. More than one option can be applied in the same way as when adopting a single option. In this case, two or more options should be applied by individually optimizing respective options and re-optimizing inter-operationally if necessary. When energy-saving options are adopted not in a single carrier or independent service line but in local transportation systems and/or large transportation networks, the applied option should be optimized in the same way as when more than one option is applied.

6.4 Conformation of the performance of smart transportation after introduction

6.4.1 General

The system of smart transportation for energy saving should be regularly monitored to determine whether transportation energy is still saved by smart transportation and where it is improved, by confirming that adopted energy-saving options are individually working. When more than one energy-saving option is applied, monitoring should be organized by following the procedure designated in 7.2. It should be noted that some individual options could have a negative impact if not well planned.

6.4.2 Monitoring of smart transportation performance when applying more than one energy-saving option

When applying more than one energy-saving option, individual options adopted should be monitored to derive synergy enhancing their respective effects and leading to the performance and effectiveness expected by combing more than one option.

7 Maintenance of the quality of smart transportation for energy saving

7.1 General

To maintain the intended performance of smart transportation, and to confirm its effectiveness, the periodical examination of the parameters in 7.2 is recommended.

7.2 Parameters for comparing smart transportation performance

The parameters for comparing smart transportation performance are listed below, and can be observed with the appropriate units:

— amount of transportation energy saved in the target area where smart transportation is introduced;

— required capacity of smart transportation;

— parameters developed based on proven measures for transit performance.

7.3 Modification of smart transportation

When no change is found in the value of the parameters designated in 7.2, the conditions of the energy-saving options, not on the principle but on the procedure, including technical parameter values, should be changed. In this case, the smart transportation conditions can be corrected by confirming anything unexpected at planning or any irregularities due to specific local situations in the area where smart transportation was introduced. The current conditions of the smart transportation system can be modified by making sure that irregular conditions are acceptable.

8 Long-term optimization of smart transportation for energy saving alongside generational and social changes

8.1 General

In general, technologies will be improved or discarded to follow the latest demands, taste and culture which result from generational change or changing social trends. Any transportation services will then be adjusted according to this. To optimize the long-term performance of smart transportation for energy saving, the capacity provided by applied energy-saving options should be regulated for the increase or decrease in the energy consumption scale in the target transportation.

8.2 Optimization of smart transportation for current and future cities and city zones

To maintain the effectiveness of energy-saving, the performance of smart transportation should be optimized for cities or city zones by choosing/discarding/improving existing energy-saving options or employing new options created by developments and innovations in technology, even after the introduction of smart transportation.

8.3 Maintaining/discarding adopted energy-saving options

As mentioned in 8.1, the capacity of current energy-saving options should be checked at certain time intervals for their suitability and applicability to the target transportation. This is helpful in managing the energy-saving options and making decisions on whether to maintain or discard these or smart transportation itself. The cost for this review, even in the long term, would be lower than that for discarding the options.

8.4 Reselection of energy-saving options

When discarding current energy-saving options, alternative options should be reconsidered for adoption.

Annex A
(informative)

Typical energy-saving performance in railway operation by modifying speed profiles

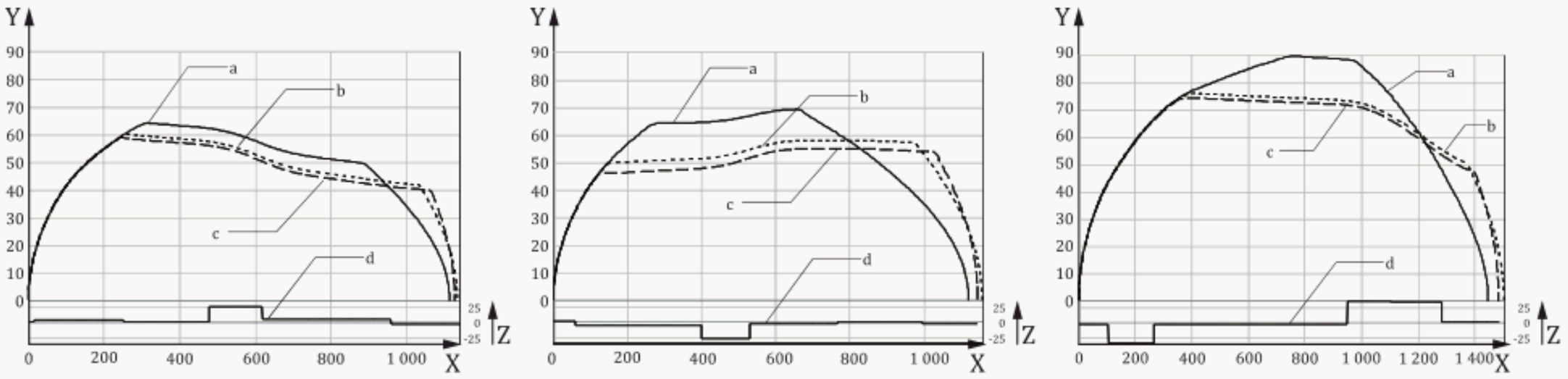
The energy consumption of electric trains was measured on railway lines in service to show how energy saving can be achieved by modifying speed profiles of train operation using buffer time created in a target section[3].

Table A.1 lists actually measured electric energy consumption in kWh. Because common modern electric railway vehicles can generate power when braking in order to make up for energy consumed while driving, the energy consumption in appearance is produced by deducting energy generated by braking from that consumed by acceleration.

Three speed profiles in each section were compared, in which the running time difference is negligible, as illustrated in Figure A.1. This figure indicates that the speed profile of Operation B6N is the most effective in reducing energy consumption. Coasting a train without powering within a fixed schedule results in effective energy saving in railway operation.

Table A.1 — Energy consumption when modifying speed profiles in railway operation

Section	**Running time** s			**Energy consumption** kWh		
	Operation B2N	Operation B4N	Operation B6N	Operation B2N	Operation B4N	Operation B6N
A	102,8	102,3	101,3	12,07	11,03	11,02
B	98,5	99,5	99,3	5,73	4,32	4,30
C	102,5	105,0	102,5	16,86	13,53	13,48



a) Section A **b) Section A** **c) Section C**

Key

X distance (m)
Y speed ($km \cdot h^{-1}$)
a Operation B2N.
b Operation B4N.
c Operation B6N.
d Track gradient.
Z gradient (%)

NOTE Running time difference is negligible between the three operations in each profile.

Figure A.1 — Differently modified speed profiles of a train in three different active service sections

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