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

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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

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

Introduction

Energy saving is one of the typical and measurable issues to be solved in every city in the world. Energy is consumed whenever citizens move in and between cities by using transportation services for their daily living and business activities. The energy consumption volume is large compared to that used by other city functions such as water and ICT systems as transportation systems convey a large number of passengers and delivery items/freight, which can be so heavy, at a time with heavy and large vehicles at a high speed. Smart transportation is not necessarily an infrastructure but definitely a solution to solve city issues found or coming-up, as pointed out in ISO 37154: 2017, "Best practice guidelines for transportation"[1]. Smart transportation works to overcome specified city issues by properly applying specific transportation services thereto. Transportation operation itself will be targeted and expected for drastic energy saving in a city, as such large consumption also includes consumption in transport procedures wasting energy that are not recognized, concerned or found. Smart transportation for energy saving is, therefore, all-important to enhance city performance, quality and potential.

The principle of smart transportation for energy saving depends not only on transportation modes but on traction ways to run transportation vehicles, because energy is consumed mainly when driving vehicles. Besides the energy for traction, energy is still consumed additionally to support dispatch operations and organize transportation's entire systems. Thus, in the transportation field, not only operation but other targets exist where energy can be saved. To successfully save transportation energy, the entire structure of transportation systems should be studied. This enables finding which situation or where energy can be saved in transportation systems and who in charge or related to transportation services can contribute to energy saving. Options are available to save transportation energy in different ways. By combing the options, energy can be more effectively saved in transportation which consists of a variety of technical fields and contents supporting the system.

This document describes just 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 that fully explains the structures, aspects and features of transportation operation, services and business from different viewpoints of those who use, plan and provide or operate transportation systems. This document also conducts specific ways to save energy consumed in transportation operation and services.

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

1 Scope

This document describes guidance to save energy that is being and to be consumed in transportation in cities and city zones, which is provided to passengers, delivery items, freight and postal items.

This document does not designate specific procedures to save energy but instructs how to properly select practical options to save it and adopt in transportation systems that are organized in different locations, scales and purposes.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purpose 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 http://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
transportation energy
energy being/to be consumed in transportation operations and services

3.2
energy saving
implementation to solve a city issue of reduction in transportation energy in cities and city zones

3.3
city zone
area that holds 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 (large) city zone holds only one core city therein but some hold more than one core city as well, which is called a megalopolis. Typical city zones that hold more than one core city are three megalopolises named BosWash (the US), Blue Banana (Europe) and the Tokaido Megalopolis (Japan).

4 Fundamentals

4.1 Basic ideas and goals

As ISO 37154: 2017, "Best practice guidelines for transportation"[1], pointed out, any smart transportation has basic ideas and goals. Such ideas and goals can also be considered according to the

criteria listed below, even while one for smart transportation, which is specified as energy saving, is arranged in transportation operation and services in cities and city zones:

— 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 preserve and enhance scenic, aesthetic, historic, community and environmental resources.

Smart transportation for energy saving is to be organized to achieve the basic ideas and goals derived from the criteria listed above.

Smart transportation for energy saving contributes to and aims at satisfying Sustainable Development Goals by United Nations, especially Goal 3 “Good health and well-being,” Goal 7 “Affordable and clean energy,” Goal 8 “Decent work and economic growth,” Goal 9 “Industry, innovation and infrastructure,” Goal 11 “Sustainable cities and communities,” Goal 12 “Responsible consumption and production,” Goal 13 “Climate action” and Goal 15 “Life on land.”

4.2 Location and objects of smart transportation for energy saving

4.2.1 General

This clause points out the location where smart transportation for energy saving is adopted in cities and city zones. In general, transportation organized in cities and city zones consists of single carriers, independent service lines, local transportation systems and/or large transportation networks. Thus, energy saving in transportation operation and services can still be applied to individual specific carriers, service lines, local transportation systems and large transportation networks while it can also be applied to an entire transportation system containing some or all of them in cities and city zones.

Besides transportation system route extents, the energy to be saved is not necessarily only the energy consumed by running transportation vehicles but also that used indirectly or additionally for vehicle operation, namely, the energy used for lighting, air-conditioning, passengers’ access assistance equipment in stations, ticketing and ticket inspection systems, passenger addressing systems, vehicle accommodation, transportation operation and maintenance systems including signaling, communication, powering and safety systems, all being work done at maintenance facilities and on service lines, and so on. Thus, energy saving works to partly or entirely reduce energy consumption in transportation operations and services.

4.2.2 Location to adopt smart transportation

Smart transportation for energy saving can be adopted in the following locations:

— within a region in a city and a city zone;

— on routes that connect regions;

— on interfaces of transportation inside/outside cities and city zones.

For transportation users, the factors that shape the locational needs of smart transportation are:

— current costs of the transportation system;

— environmental impact of current transportation activities.

4.2.3 Objects to adopt smart transportation

Smart transportation for energy saving can be adopted in transportation operations and services with the following purposes:

— to transport people, freight and goods safely, reliably, conveniently, efficiently and economically;

— to provide transportation services that satisfy demand;

— to reduce environmental impact without reducing the quality of the transportation services;

— to improve the efficiency of connections between different modes of transportation;

— to reduce the total energy usage of the transportation infrastructure;

— to make transportation operation economically sustainable while ensuring it is affordable and accessible to all users;

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

The above-mentioned objectives can be achieved by ensuring the transportation system's effective performance for the following:

— to convey passengers, delivery items and freight safely;

— to convey passengers, delivery items and freight, especially when they are in a large lot;

— to convey passengers, delivery items and freight at one time;

— to convey passengers, delivery items and freight on time;

— to convey passengers, delivery items and freight as planned;

— to convey passengers, delivery items and freight at a low cost;

— to provide dense networks for transport;

— to provide frequent services for transport;

— to provide successful and easy connection for transport between different transportation systems or modes;

— to control total energy saving/consumption for transportation;

— to lower environmental load without degradation in service quality of transport operations.

With integrated urban transportation planned, the 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 saving/consumption for transportation;

— the lowering of environmental impact without degradation in service quality of transport operation;

— the economically stable operation of transportation with fares that are reasonable or payable by local citizens.

5 Targets of smart transportation for energy saving

5.1 General

This clause describes how smart transportation for energy saving targets transportation system structures. As described in ISO 37154, transportation systems are characterized by transportation modes applied, each of which has transportation technical and business contents dependent on the mode. Transportation technical and business contents provide transportation services to transportation users. Thus, smart transportation for energy saving targets all or part of transportation system 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 transportation modes listed below, which are also transportation modes of smart transportation in a general meaning defined by 3.7 in ISO 37154:

— rail;

— commuter buses/bus rapid transit/inter-city 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, conveyers);

— 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 will be adopted in transportation organized for public or private purposes in cities and city zones, by targeting the technical and business contents that the transportation mode has.

5.2.2.2 Public transportation

Public transportation is organized for specified purposes or what and from where to where the transportation conveys. Smart transportation targets technical and business contents of the transportation mode used in public transportation.

a) Rail mode

— passenger, delivery of items and freight services (e.g. customer services at stations and freight yards, refrigerators for delivery items/freight to be kept at low temperature);

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

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

— rolling stock (e.g. accommodations, maintenance, refrigerators for delivery of items/freight to be kept at low temperature);

— power/signaling;

— communication for train operations;

— facilities (e.g. stations, tracks, civil engineering structures);

— safety (e.g. surveillance);

— the environment (e.g. noise, vibration, pollutant and greenhouse gas emission, sunlight);

— information availability (e.g. making real-time information available to passengers about service frequency, routing, destinations and cost).

b) Bus/truck modes

— passenger, delivery of items and freight services (e.g. customer services at bus stations, refrigerators for delivery items/freight to be kept at low temperature);

— bus and truck operations (e.g. scheduling, dispatching, drivers and conductors);

— refueling/power charging;

— signaling/bus tracking systems;

— communication for bus/truck operations;

— vehicles (e.g. accommodations, maintenance, refrigerators for delivery of items/freight to be kept at low temperature);

— facilities (e.g. bus stations, freight yards, taxi stands, bus and truck lanes on public roads, bus tracks, civil engineering structures for bus/truck operations);

— information availability (e.g. making real-time information available to passengers about service frequency, destinations and cost).

c) Ferry mode

— passenger, delivery of items and freight services (e.g. customer services at ports, refrigerators for delivery items/freight to be kept at low temperature);

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

— refueling/power charging;

— signaling;

— communication for ferry operations;

— vessels (e.g. accommodations, maintenance, refrigerators for delivery of items/freight to be kept at low temperature);

— facilities (e.g. ports, ferry terminals, civil engineering structures for ferry operation);

— information availability (e.g. making real-time information available to passengers and senders/recipients about service frequency, destinations and cost).

d) Air vehicle mode

— passengers, delivery of items and freight services (e.g. customer services at airports, refrigerators for delivery items/freight to be kept at low temperature);

— refueling/power charging;

— air vehicle operations (e.g. scheduling, dispatching, crew);

— aircrafts (e.g. pilot-less aircrafts);

— facilities (e.g. airports, civil engineering structures for aircraft operation).

5.2.2.3 Private transportation

For private transportation, services listed below are provided to the owners and the drivers or operators of the transportation by the responsible governmental, government-related organizations or manufacturers in charge. Smart transportation for energy saving targets the services.

— work by road administrators (e.g. traffic surveillance, road maintenance, street lights, lighting for signboards);

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

— work by air traffic authorities (e.g. air-way beacons);

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

— work by fire departments;

— work by vehicle, boat and air vehicle manufacturers;

— green spaces or complete streets dedicated for walking and bicycles;

— bicycle-sharing services.

5.2.2.4 Public transportation for personal use

Smart transportation for energy saving not only targets public but personally-used transportation.

— rental bicycles (e.g. batteries, recharging devices);

— rental motorbikes (e.g. batteries, recharging devices);

— rental cars (e.g. batteries, recharging devices).

5.2.3 Target services of transportation

5.2.3.1 General

Smart transportation for energy saving targets services of transportation as listed below, which are provided by using transportation's technical and business contents for benefit of transportation users:

5.2.3.2 Public transportation

a) Passenger services

- train/bus/ferry/air vehicle operations;
- safety for driving;
- weather forecast and information;
- communication of emergencies;
- travel planning;
- easy access to stations, ferry terminals and airports (e.g. pathways with roofs, access formation to connect stations, bus stops, ferry terminals and airports, introduction of passengers);
- ticketing;
- ticket inspection (e.g. at stations, in coaches);
- fare collection;
- connections and changing;
- inter-modal connections (e.g. rail and buses/trucks, rail and ferries, buses/trucks and ferries);
- connecting operations, including vehicle run-through operations (e.g. between different rail carries, between sections with different-gauge tracks);
- information provision and indication (e.g. announcement 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 whose physical performance is declining;
- 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 station and bus stop intervals considering distance;
- business introduced into transportation facilities other than transportation services (e.g. nurseries, polling places);
- coach accommodations (e.g. formation, service equipment);
- delay minimization;
- optimization of the passenger capacity of coaches or train sets/buses/ferries/air vehicles;
- electronic fare payment through banks;
- variety of choices of traveling means;
- arrangements at time of emergency (e.g. providing detours by other carries or transportation modes);

— emergency measures (e.g. fire apparatus, rescue vehicles, firefighters, ambulances, escape routes, terrorist attacks, natural disasters, 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 fare.

b) Delivery of item/freight services

— train/bus/truck/ferry/air vehicle operations;

— safety in driving;

— weather forecast and information;

— communication at emergency;

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

— shipping/receiving planning;

— pick-up/delivery services;

— storage services;

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

— packing/unpacking services;

— safe-handling for 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 through banks;

— pick-up/delivery services in a building or an area;

— door-to-door pick-up/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);

— 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, terrorist attacks, natural disasters, traffic accidents);

— energy stations (e.g. gas, LPG, electric power, hydrogen);

— parking lots;

— vehicle sharing;

— rental vehicles;

— dedicated bicycle lanes.

b) Pooling vehicles

— rental bicycles;

— rental motorbikes;

— rental cars.

6 Adoption of smart transportation for energy saving

6.1 General

This clause describes selection and adoption of the practical options to be applied in smart transportation for energy saving.

6.2 Adoption of smart transportation

6.2.1 General

Smart transportation for energy saving is adoptable in operation that is arranged in the same and among different transportation modes and on the interface between public and private transportation.

6.2.2 Services in the same transportation operation mode

In the same transportation mode, smart transportation is adopted also in an operation arranged for through-transportation transport, besides transportation operated by a single carrier or a rail track/road/airway owner or manager:

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

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

— ticketing for travel to other carriers;

— arrangements for shipping to other carriers;

— long distance and high speed transportation (e.g. inter-city 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 spots).

6.2.3 Inter-modal services

Among different transportation modes, smart transportation is adopted in an operation arranged for inter-modal transport:

— 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/through service lines by other carriers;

— communication with other carriers on travel by the disabled, elderly and those whose physical performance is declining;

— arrangements for shipping to different-mode carriers;

— reshipment of delivery items and freight at junctions.

6.2.4 Services involving interface between public and private transportation

Between public and private transportation, smart transportation is adopted in transportation services organized to provide users with easy changes from public to private transportation and vice versa. The services are listed below:

— temporary stops for private vehicles;

— assistance to the disabled, elderly and those whose physical performance is declining with changes between public and private transportation;

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

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

— on-board transport services for private vehicles including bicycles, motorbikes and cars;

— private vehicle shipment;

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

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

— convenient access for persons 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, inter-net access areas, fast-food shops, restaurants, public phones, bank ATMs (automatic teller machines) and so on.

6.3 Selection of practical options for energy saving

6.3.1 General

To save transportation energy, as mentioned in 4.2, the target section/line/area where smart transportation for energy saving is adopted depends on the situations or goals that the city or city zone has. The extent that smart transportation is adopted will fall on a target from a single carrier or independent service line/section to a local transportation system, up to a large transportation network. The extent as to how totally energy saving is planned or expected will depend on how many

practical options are applied; say, only one option is simply used or more than one are combined to save transportation energy more totally.

6.3.2 Practical options for energy saving

The following practical options can be applied by considering target transportation modes, technical/business contents and services, for example. More options would be developed when the technologies are confirmed for practical use.

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

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

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

— by evaluating driver's skill in driving vehicles.

6.3.3 Criteria and parameters to be considered in the selection of practical options for energy saving

The following criteria should be taken into consideration when selecting appropriate practical options to save transportation energy. Normally, the larger the target section/line/area where smart transportation for energy saving is adopted, the higher the cost to adopt smart transportation. The wider the energy saving planned or expected, the higher and more complicated the cost of the adoption and the control of the smart transportation system, respectively. In contrast, the more extensively and totally that smart transportation is adopted, the more effectively the energy saving performs.

— 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 adopted;

— power capacities where smart transportation is adopted, in case the service line/section is electrified;

— rolling stock performance where smart transportation is adopted;

— service line planning where smart transportation is adopted.

6.4 Adoption of the practical options for energy saving

When only one practical option is used, it is simply applied to the targeted single carriers, independent service lines, local transportation systems and/or large transportation networks. More than one practical option can be applied in the same way as that for single practical option adoption. In this case, two or more practical options are applied. Thus, the applied practical options should be inter-optionally optimized even while respective practical options contained are individually optimized. When practical options are applied not in a single carrier or independent service line but in local transportation systems and/or large transportation networks, the applied practical option should be optimized in the same way as when more than one practical option is applied.

7 Confirmation of the performance of smart transportation for energy saving after adoption

7.1 General

The system of smart transportation for energy saving in cities and city zones should be regularly monitored to determine whether energy saving is still being provided by smart transportation and where improvements should be focused, by confirming that selected practical options are individually working. When more than one practical option is applied to save transportation energy, monitoring should be organized by following the procedure designated in 7.2.

7.2 Monitoring smart transportation performance when more than one practical option is applied

Basically, even when using more than one practical option to save transportation energy, individual practical options applied should be monitored to derive synergy enhancing their respective effects resulting in the performance and effectiveness that are expected by combing more than one practical option. To enable these individual practical options to contribute to performance and effectiveness, each practical option organically arranged is monitored.

8 Maintenance of the quality of smart transportation for energy saving

8.1 General

To keep the performance of smart transportation for energy saving in conditions planned and confirm the effectiveness thereof, observe the parameters below periodically. If the effectiveness of smart transportation is not confirmed or not clear, modify the current services by smart transportation by changing the conditions of the practical options for energy saving, where possible and reasonable.

8.2 Parameters to be observed

To make sure of the performance of smart transportation, observe parameters indicated below to compare:

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

— changes in the required capacity of smart transportation;

— parameters developed based on proven measures for transit performance.

8.3 Modification of smart transportation

When identifying unwanted changes in the value of the parameters designated in 8.2, modify the conditions of the practical options, where possible. To correct the practical option conditions, analyze any unexpected or irregular occurrences in those areas where smart transportation was adopted. Modify irregular conditions of the practical options in case the irregular conditions are not acceptable.

9 Optimization of smart transportation for energy saving along with generation and social trend changes

9.1 General

In general, technologies will be improved or discarded along with changes in demands, taste and culture while generations alternate or social trends change. Then, any transportation services are optimized to follow the latest states or situation taking place to cities and city zones currently existing and expected

in the future. To optimize the performance or capacity of smart transportation for energy saving in such situations, smart transportation should be improved, changed or discarded to successfully provide a smart transportation solution or energy saving even while such changes come up in cities and city zones.

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

To continuingly make the solution given by smart transportation advantageous to the transportation users and operators, city or city zone governors, planners or developers, performance or capacity of smart transportation for energy saving should be optimized for the situation of cities or city zones currently existing and expected in the future by choosing/discarding practical options for energy saving, improving them or introducing new practical options created with developed or innovated technologies.

9.3 Holding/discarding smart transportation adopted in currently existing cities and city zones

To prepare suitable performance or capacity given by smart transportation for energy saving, the practical options for energy saving should be chosen/discarded, employed or changed, if necessary. The options currently adopted should be checked at certain time intervals for their suitability and applicability to the target transportation, which provide the performance or capacity of energy saving offered/to be offered to current and expected cities and city zones.

9.4 Reselection of practical options for energy saving adopted in currently existing cities and city zones

To successfully organize smart transportation for energy saving by making the performance or capacity of adopted practical options suitable to cities and city zones currently existing and expected in the future, the options that have been used should be reconsidered. The decision to hold or reselect the options should be made by the transportation operators, city or city zone governors, planners or developers.

Annex A
(informative)

Typical energy saving performance in railway operation by modifying speed profiles

The energy consumption by electric trains was measured on railway lines in service to show how energy saving can be achieved by modifying speed profiles of train operation by using buffer time created in a target section[2].

Table A.1 — lists actually-measured electric energy consumption in kWh. Because common modern electric railway vehicles can generate power at a brake in order to make for energy consumed while driving, the energy consumption in appearance is given by deducting energy generated by making a brake 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. The Figure indicates that the speed profile of Speed B6N is the most effective to reduce energy consumption in appearance. To save energy in railway operation, it will be successful to run such a power-regenerative train coasting as long as train schedules permit.

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

Section	Driving type	Running time (s)	Energy consumption (kWh)
A	Speed – B2N	102.8	12.07
	Speed – B4N	102.3	11.03
	Speed – B6N	101.3	11.02
B	Speed – B2N	98.5	5.73
	Speed – B4N	99.5	4.32
	Speed – B6N	99.3	4.30
C	Speed – B2N	102.5	16.86
	Speed – B4N	105.0	13.53
	Speed – B6N	102.5	13.48

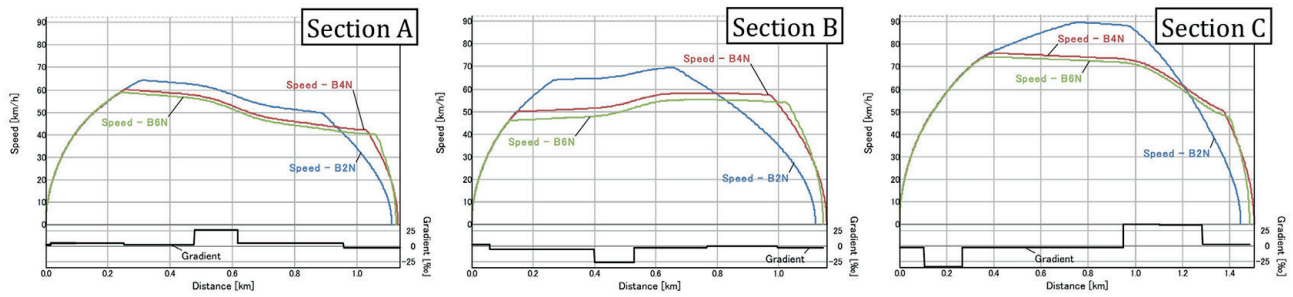

Figure A.1 — Differently modified speed profiles of a train, which were tried in three different active sections but the running time difference is negligible between them.

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[1] ISO 37154:2017, *Smart community infrastructures — Best practice guidelines for transportation*

[2] OGAWA T., et al. *Verification Test of Energy-Efficient Driving by Selection of Braking Notche, IEEJ Transactions on Industry Applications, 134(12): 1022-1030 (* 2014*)*