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SYSTEM OF KEY PERFORMANCE INDICATORS FOR MONITORING THE EFFECTIVENESS OF URBAN PUBLIC TRANSPORT

Summary. This article presents a systematic framework of metrics intended to evaluate the fundamental operational activities of urban public transport operators. The indicators include operational, financial, qualitative, safety, environmental, technological, and social aspects. Additionally, the paper presents comprehensive algorithms for calculating and monitoring these metrics on an ongoing basis. An essential component of the suggested methodology is the selection of indicators that conform rigorously to SMART criteria: specific, measurable, achievable, relevant, and time-bound. The analysis encompasses critical elements, including passenger flow on routes, timetable compliance, ticket and subscription revenue, profit per passenger, subsidies, passengers' and employees' satisfaction levels, and environmental and technical advancements. This article presents a systematic approach for accurately measuring and interpreting key variables based on a thorough examination. The established set of key performance indicators provides a foundation for transport operators, facilitating efficient management, resource optimization, improved customer satisfaction, and financial sustainability. This paper also examines the potential for integrating mobile and intelligent transportation technology, highlighting the need for personnel training to attain sustained operational excellence. The paper concludes with advice for adopting innovative solutions and sustainable practices to promote the future prosperity of transport operators. The results have been verified within the operating framework of "Municipal Transport Ruse" Ltd.

1. INTRODUCTION

Urban public passenger transport is essential for delivering sustainable and effective transportation services in urban areas. It substantially aids in alleviating traffic congestion, improving quality of life, and safeguarding the environment [1]. In light of rapid technological advancements, increasing environmental regulations, and shifting societal demands, the efficient management of urban transportation systems has become crucial for municipalities [2]. In this environment, revising the business strategies of public transport providers is crucial to align their services with contemporary conditions and to attain sustainable development.

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This article focuses on developing a set of key performance indicators to assess the efficacy, sustainability, and financial viability of transportation services. The objective is to develop a holistic strategy for resource management, route optimization, service quality improvement, and a transition to more environmentally friendly and innovative solutions through these indicators.

The analyzed subjects encompass essential elements of evaluating and overseeing transportation services, including the identification of suitable indicators for measuring progress and efficacy. The analysis is framed within the challenges encountered by “Municipal Transport Ruse” Ltd., alongside other entities operating in the contemporary dynamic and competitive landscape.

Managing urban public transportation services is a multifaceted endeavor that requires a cohesive strategy to guarantee sustainability, efficiency, and service excellence. Key performance indicators (KPIs) are utilized to monitor, evaluate, and regulate transportation systems, analyzing diverse operational facets.

The efficacy of public transportation services can be assessed through three primary dimensions: operational efficiency, economic efficiency, and social efficiency. Operational efficiency involves the utilization of resources, such as time, vehicles, and personnel, to maximize productivity while minimizing expenses. Economic efficiency evaluates transport operators’ ability to produce revenue, manage costs, and attain financial sustainability. Social efficiency pertains to the accessibility, equity, and social integration of transportation services [3, 4]. These dimensions are evaluated by several criteria, including passenger and kilometer costs, route occupancy, service duration, and passenger satisfaction.

Essential metrics for assessing urban public transport efficacy are categorized into financial, operational, qualitative, safety, environmental, and social dimensions. Financial indicators assess the sustainability of transportation firms, including ticket revenue, per-kilometer expenses, and investment return periods [5, 6]. Subsidies also function as a crucial measure of financial stability and external dependency [7]. Operational indicators encompass route occupancy, travel duration, vehicle intervals, and route network optimization, and they offer insights into existing service conditions and indicate possibilities for route and resource enhancement. [8, 9]. Qualitative indicators, which encompass cleanliness, comfort, schedule adherence, and passenger satisfaction [10], are assessed by surveys, mobile applications, and passenger feedback [5, 11]. Safety indicators encompass both collision and non-collision hazards across the complete travel continuum, including boarding, alighting, and in-vehicle motions. They include accident incidence, injury severity, and safety compliance assessments. Prioritizing safety as a key performance indicator not only supports regulatory objectives and reduces accidents but also enhances accessibility and fosters passenger trust. Additionally, building a strong safety culture through careful planning, combining social and technical aspects, and training employees significantly reduces incidents and improves overall service quality [12]. Environmental indicators encompass carbon emissions, the proportion of electric vehicles, and the utilization of renewable energy, which are essential for adopting environmentally sustainable practices [5, 7]. Simultaneously, social indicators assess employee satisfaction, service safety, and accessibility for various social groups, including individuals with disabilities, ensuring that public transport services fulfill community requirements and uphold social responsibility [2]. Research demonstrates that motivated and trained personnel constitute the cornerstone of effective transportation services [13]. Employee satisfaction influences productivity and, subsequently, the quality of passenger service.

Globally, the populations of developed countries in Europe, Asia, North America, and Australia have the greatest accessibility to public transport and satisfaction with the service at over 85%, whereas the global average is 64.7%. The lowest results are observed in Africa and South America [14].

Policies introduced to reduce emissions from transport sometimes contradict the implementation of quality public transport [15]. In this regard, a compromise option has been proposed for transport in China, which is actively pursuing a development strategy with the goal of decarbonization by 2060. Authors from New Zealand performed a multi-criteria analysis of the reduction of emissions from transport and proposed increasing investments in active and public transport as the most acceptable option [16], followed by a strict measure to stop the import of gasoline and diesel vehicles into New Zealand by 2030.

Digitalization and intelligent transport systems substantially enhance the efficiency of public transportation services. Similar solutions have been implemented to simultaneously achieve a balance between the efficiency and sustainability of urban transport [17]. The results of this study show a direct link with the development of intelligent transport systems. Key technologies encompass GPS monitoring, mobile navigation applications, traffic forecasts, real-time passenger information, automated route management systems, dynamic schedule adjustments, and transport flow optimization. Moreover, big data analysis facilitates demand forecasting and route optimization based on user behavior. This enhances operational efficiency and customer service by minimizing waiting times and expenses while boosting the accuracy and dependability of transportation services [9]. A detailed study was done in [18] in which data were collected from citizens traveling to work, and models were created to determine the best mode of public transport for commuting to work.

Effectively managing urban public transport necessitates a comprehensive approach that balances financial, operational, qualitative, environmental, and social considerations [6, 19]. The incorporation of new technology and the utilization of intelligent transport systems are essential catalysts for the advancement and sustainability of the transportation sector.

Various models and monitoring systems have been established to guarantee precise and dependable information regarding transport service performance. These models differ based on the type of transportation network (urban, intercity, and international) and the associated municipal or national legal frameworks, technologies, and conditions. The primary objectives of these models are to enhance the management efficiency of the transport network, furnish data for service quality assessment, evaluate environmental impact, facilitate resource planning, optimize costs, and identify areas for service development.

Key models for performance evaluation comprise:

- balanced scorecard;
- evaluation models based on key performance indicators;
- sustainability and environmental impact assessment models;
- life cycle analysis;
- intelligent transport systems and real-time monitoring.

The balanced scorecard methodology is extensively utilized, providing a holistic perspective on the performance of transportation companies via four primary categories of indicators: financial, customer, internal business processes, and learning and growth. It facilitates the evaluation of short- and long-term objectives, reconciling financial management with service quality and personnel development. Examples include ticket income, vehicle maintenance expenses, passenger satisfaction, and loyalty. This technique enhances the integration of various organizational facets and yields valuable insights for service enhancement [6, 20].

KPI-based models evaluate public transport efficacy using indicators such as vehicle productivity (e.g., the number of daily trips or vehicle mileage), resource utilization (e.g., seat occupancy or route congestion), waiting times, schedule adherence, and passenger satisfaction. Challenges frequently emerge in real-time data gathering and analytical technologies, yet these systems proficiently validate service quality, exemplified by passenger flow management systems that evaluate passenger counts and vehicle occupancy in real time [3, 8].

The study of environmental impact is essential in assessing public transport performance, employing models to quantify CO₂ emissions, energy consumption, and infrastructure sustainability. These models encompass the calculation of the carbon footprint of transportation services, the efficiency of fuel consumption, and the sustainable management of energy resources. The implementation of electric or hybrid vehicles and buses can substantially diminish carbon emissions and contribute to a broader strategy for pollution reduction [5].

In order to influence society, the authors in [21] analyzed pricing, taking carbon footprint into account. The results show that the use of green transport can facilitate the reduction of carbon emissions and reduce congestion on the streets by developing policies and encouraging urban transport systems to operate for the benefit of society. Serious measures have been taken in Poland, where 7.4 billion euros have been invested in green transport per the requirements of a low-carbon economy, through European Union funds [22].

Life cycle analysis evaluates environmental impacts across vehicle lifecycles – from manufacture to recycling – enhancing resource efficiency and reducing ecological harm. Life cycle analysis facilitates resource optimization and mitigates environmental damage. Vehicle footprint management systems can quantify not only CO₂ emissions but also additional environmental impacts, including water consumption and waste generation [9].

Intelligent transport systems provide novel potential for the real-time monitoring of public transportation through technologies such as GPS tracking and telematics. This enables transport operators to gather and analyze data in real time. Traffic management systems and passenger information platforms offer extensive operational insights, improving responsiveness and facilitating route and resource planning [9].

The presence of several performance monitoring models and methods is essential for sustainable public transport management. The integration of KPI methodologies, balanced systems, life cycle analysis, and intelligent transportation technology allows operators to utilize resources efficiently, enhance outcomes, and promote sustainability and social responsibility.

2. METHODS

2.1. Methodology for developing a system of key performance indicators to assess the effectiveness of urban public transport

The development of a key performance indicator system commenced with the identification of the strategic objectives and priorities of the transport operator. Consequently, indicators were chosen that represent these objectives across multiple dimensions of transportation activity, including efficiency, sustainability, and service quality. This selection was based on an analytical and synthetic approach that scrutinized current monitoring models and tailored them to local conditions and the specific environment of the transportation sector.

The establishment of a KPI system for assessing the efficacy of urban public transport can be delineated into four phases (Fig. 1).

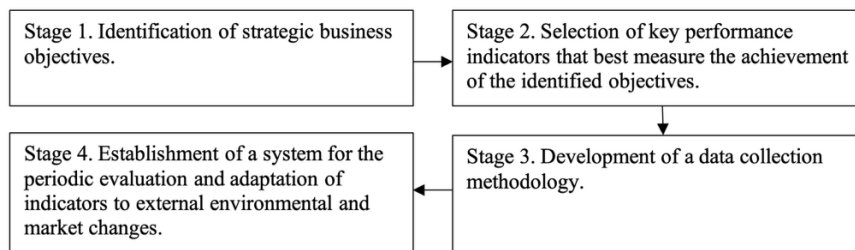


Fig. 1. Process of developing a key performance indicator system

The strategic objectives extracted from the business plan of Municipal Transport Ruse that are presently relevant to the majority of transport operators are:

- Cost optimization and revenue enhancement: Financial metrics, including passenger costs and revenues, allow management to assess service profitability and implement corrective measures if costs surpass revenues.
- Enhancing service quality and passenger satisfaction: Qualitative metrics, including passenger satisfaction and overall service quality, offer insights into passenger perceptions and service standards, including vehicle cleanliness and comfort.
- Sustainable development and minimizing environmental impact: Environmental indicators such as emission metrics and energy efficiency facilitate strategic objectives focused on diminishing pollution and improving energy efficiency via the implementation of green technologies and sustainable practices.
- Social responsibility and accessibility: Social indicators, including network accessibility and passenger safety, guarantee that the transportation system is available to all demographic groups, fostering a safe and secure travel environment.

Every category of indicators is essential for attaining the company's strategic goals, providing varied insights into public transport management and service performance efficacy.

Table 1 presents the selection of key performance indicators that effectively assess the attainment of strategic objectives, together with the data-gathering methods necessary for developing a complete monitoring and assessment system. A significant challenge is the availability of reliable data for all key metrics. Transport companies must invest in sophisticated data-gathering and analytical technology, including GPSs for bus tracking and platforms for passenger feedback. Insufficient or inaccurate data may result in incorrect conclusions and decisions.

Table 1

Key Indicators for Monitoring

Primary Categories	Key Performance Indicators (KPIs)	Measurement	Data / Methods of Measurement
1. Financial	1.1. Revenues from tickets, passes, and compensations; total revenues from sales of tickets, passes, and compensations.	Determination of the financial efficiency of the service.	Recording of ticket and pass sales from various channels (ticket offices, online platforms, onboard purchases), including compensation revenues.
	1.2. Cost per kilometer for passenger transport; average transport cost per passenger per kilometer.	Average transport cost per passenger per kilometer.	Ratio between total operating costs and total vehicle mileage.
	1.3. Profit per passenger; net profit per passenger, calculated as the difference between revenues and costs of service.	Optimization of revenues and expenditures.	Calculation of net revenue per passenger.
	1.4. Share of subsidies in total revenue; percentage of public subsidies in relation to total revenues.	Determination of dependency on state or municipal subsidies.	Analysis of financial statements and public funds.
2. Operational	2.1. Timeliness of service; percentage of delayed vehicles.	Improvement of schedule adherence and punctuality.	GPS monitoring systems compared against scheduled timetables.
	2.2. Route occupancy; average number of passengers per day per route.	Evaluation of transport demand and main route occupancy.	Passenger registration on vehicles.
	2.3. Punctuality of vehicles; adherence to schedules.	Improvement of service regularity and availability.	Waiting times at stops tracked via GPS or mobile applications.
	2.4. Share of routes with full coverage; percentage of routes fully and regularly served without interruptions.	Ensuring maximum accessibility for passengers.	Comparison of executed routes with planned route schedules.
3. Quality	3.1. Passenger satisfaction; survey-based passenger satisfaction scores.	Enhancement of customer service and public transport reputation.	Passenger surveys and feedback scores.
	3.2. Cleanliness and comfort of vehicles; average cleanliness and comfort index as rated by passengers	Improvement of travel quality and passenger comfort.	Regular inspections of vehicle condition and surveys on comfort levels.
	3.3. Share of addressed complaints; percentage of complaints processed within designated timelines.	Enhancement of customer service efficiency.	Logging and analysis of processed customer complaints.
4. Safety	4.1. Number of vehicle incidents; number of traffic incidents involving transport vehicles	Reduction of incidents and improvement of safety.	Registration and evaluation of traffic incidents and related risks.
	4.2. Percentage of vehicles with verified safety; share of vehicles that passed regular technical safety inspections.	Improvement of vehicle technical integrity and safety.	Regular safety inspections and documentation of results.

5. Ecological	5.1. CO ₂ emissions; total amount of carbon emissions from the transport network (in tons of CO ₂).	Reduction of the environmental footprint of municipal transport.	Monitoring of vehicles' greenhouse gas emissions via integrated systems.
	5.2. Energy efficiency; total fuel and electricity consumption.	Improvement of energy efficiency.	Assessment of fuel and electricity consumption per unit of transport output.
	5.3. Share of electric vehicles in the fleet; percentage of electric buses and vehicles within the overall fleet.	Sustainable development of the transport fleet.	Fleet inventory assessments.
6. Social and Organizational	6.1. Accessibility of the transport network; route coverage across urban areas.	Geographic accessibility.	Measurement of route coverage across various city districts.
	6.2. Employee satisfaction; degree of employee satisfaction with working conditions and environment.	Improvement of internal organization and staff motivation.	Staff surveys and interviews.
	6.3. Staff training and qualification level; percentage of staff trained or certified in new technologies and services.	Enhancement of team qualification and capacity.	Analysis of training sessions and staff professional development.
7. Innovation and Technological Development	7.1. Integration of mobile platforms; percentage of passengers using mobile apps for ticketing or real-time information.	Enhancement of passenger accessibility and convenience.	Usage statistics of mobile platforms.
	7.2. Development of intelligent transport systems; degree of implementation of intelligent systems (e.g., traffic management, GPS tracking).	Increased efficiency and safety of the transport network.	Impact assessment of implemented technologies on transport operations.

The practical implementation of the key performance indicator system underpins the efficient administration of transport services provided by public transport providers. Monitoring various operational facets allows businesses to make informed decisions and implement targeted measures to maximize resource usage, improve service quality, and decrease operating expenses.

To support the analysis, this article provides formulas and methodologies for identifying key performance indicators in public transportation services. These methods facilitate the assessment of efficacy across various parameters of transportation operations.

2.2. Key performance indicators

Financial Indicators

1.1. Revenue from tickets, passes, and compensations

$$R_{ticket} = \sum_{i=1}^n B_i C_i, \quad (1)$$

Where: R_{ticket} – total revenue from tickets, passes, and compensations;

B_i – number of sold tickets, passes, or compensations of type i ;

C_i – price of type i ticket or pass;

n – number of different types of tickets/passes/compensations.

This represents the total revenue generated from ticket sales, passes, and compensations financed by state or municipal budgets. Compensations are provided for travel papers available at discounted rates, as established by the government or municipal authorities, expressed in Bulgarian Lev currency (BGN). This might be quantified as an absolute figure or as a proportion of overall public transportation revenue.

1.2. Cost per kilometer (direct costs)

$$C_{km} = \frac{Exp_{direct}}{K_{total}}, \quad (2)$$

Where: C_{km} – the cost per kilometer of transportation;
 Exp_{direct} – direct operating expenses (direct costs);
 K_{total} – total distance covered.

Direct costs are crucial for ascertaining efficient cost management in carrier operations. This excludes depreciation and analogous indirect expenses.

1.3. Profit per passenger

$$P_{passenger} = \frac{R_{in_total} - Exp_{total}}{P_{total}}, \quad (3)$$

Where: $P_{passenger}$ – net profit per passenger;

R_{in_total} – total revenue from passenger transport, including: ticket sales (single rides, subscriptions), governmental compensation or subsidies, other passenger-related income (e.g., fines, surcharges);

Exp_{total} – total operational expenditure, including energy/fuel costs, maintenance and repair, driver and staff wages, depreciation, insurance, and administrative overhead;

P_{total} – total number of passengers transported during the period (e.g., per year).

This formula represents the average net profit (or loss) generated per transported passenger and offers an understanding of trip profitability and the effectiveness of transport in utilizing passengers to generate revenue.

1.4. Share of subsidies in total revenue

$$P_{subsidy} = \frac{S_{subsidy}}{R_{in_total}} 100, \quad (4)$$

Where: $P_{subsidy}$ – the percentage of subsidies;

$S_{subsidy}$ – total subsidies received.

This indicator is significant, as it indicates the extent to which public transport depends on public financing.

Operational Indicators

2.1. Route occupancy

$$N_m = \frac{P_m}{K_m}, \text{ passenger/km}, \quad (5)$$

Where: N_m – route occupancy;

P_m – total number of passengers per route;

K_m – kilometers traveled on route m .

This formula indicates the average vehicle occupancy on routes (passengers per kilometer). Increased values often signify efficient resource utilization and conversely.

2.2. Frequency of service

$$T_{frequency} = \frac{T_{frequency_total}}{P_{total}}, \quad (6)$$

Where: $T_{frequency}$ – average waiting time per passenger;

$T_{frequency_total}$ – total waiting time of all passengers.

This formula indicates the mean waiting time for a passenger.

2.3. Punctuality of vehicles

$$P_n = \frac{V_n}{V_{total}} 100, \quad (7)$$

Where: P_n – percentage of on-time vehicles;

V_n – number of vehicles on time;

V_{total} – total number of vehicles.

This formula quantifies the percentage of vehicles arriving punctually at designated stops.

2.4. Share of routes with full coverage

$$P_{m_covered} = \frac{M_{covered}}{M_{total}} 100, \quad (8)$$

Where: $P_{m_covered}$ – percentage of fully covered routes;

$M_{covered}$ – number of routes with full service coverage;

M_{total} – total number of routes.

This formula represents the proportion of routes that are operated continuously and without interruption, guaranteeing accessibility and service reliability. It is quantified as the percentage of routes that are entirely executed following the published timetable.

Quality of Service Indicators

3.1. Passenger Satisfaction

$$U_{passenger} = \sum_{i=1}^N \frac{O_i}{N}, \quad (9)$$

Where: $U_{passenger}$ – average passenger satisfaction score;

O_i – satisfaction rating given by passenger i ;

N – number of surveyed passengers.

This indicator assesses overall contentment with urban public transportation services. It can be evaluated using surveys, interviews, or passenger ratings.

3.2. Cleanliness and comfort of vehicles

$$I_{cleanliness} = \frac{\sum_{i=1}^M O_{cleanliness}}{M}, \quad (10)$$

Where: $I_{cleanliness}$ – average cleanliness index;

$O_{cleanliness}$ – cleanliness rating of vehicle i ;

M – number of inspected vehicles.

This formula indicates the sanitary and comfort conditions of vehicles (buses, trolleybuses). Measurements may encompass evaluations of cleanliness, temperature, and seating comfort.

3.3. Percentage of complaints addressed

$$P_{complaint} = \frac{O_{process}}{O_{total}} 100, \quad (11)$$

Where: $P_{complaint}$ – percentage of complaints resolved;

$O_{process}$ – number of complaints processed;

O_{total} – total number of complaints received.

This formula displays the proportion of submitted complaints that have been evaluated and addressed.

Safety Indicators

4.1. Number of vehicle incidents

$$P_{incident} = \frac{I_{incident}}{V_{total}} 100, \quad (12)$$

Where: $P_{incident}$ – percentage of incidents;

$I_{incident}$ – number of incidents.

Denotes the ratio of occurrences (traffic accidents, breakdowns, etc.) involving public transport vehicles within a specified timeframe. The value of this indicator is inversely related to the degree of safety.

4.2. Percentage of vehicles with verified safety

$$P_{checked} = \frac{V_{checked}}{V_{total}} 100, \quad (13)$$

Where: $P_{checked}$ – percentage of vehicles inspected for safety;

$V_{checked}$ – number of vehicles that passed safety checks.

This formula quantifies the proportion of vehicles that have completed regular safety checks and comply with safety standards. Higher values signify stronger compliance.

Environmental Indicators

5.1. Carbon dioxide emissions

$$E_{CO_2} = \sum_{i=1}^N (T_i K_{CO_2} K_i), \quad (14)$$

Where: E_{CO_2} – total CO₂ emissions;

T_i – kilometers traveled by vehicle type i ;

K_{CO_2} – CO₂ emissions per kilometer for vehicle type i ;

K_i – number of vehicles of type i .

This formula measures the amount of CO₂ emissions produced by the vehicles in the system. Lower values signify a smaller environmental footprint.

5.2. Energy Efficiency

$$EE = \frac{L_{total}}{E_{total}}, \quad (15)$$

Where: EE – energy efficiency (km/kWh or km/liter), calculated as the ratio between the total mileage traveled by the fleet and the total energy consumed;

L_{total} – total distance covered by the vehicles in a given period (km);

E_{total} – total energy consumed (either in kWh or liters, depending on fuel type).

This indicator measures how effectively energy is converted into transport output. It enables comparisons to be made between different types of vehicles (e.g., diesel vs. electric) or periods. A higher value indicates better energy performance.

5.3. Share of electric vehicles in the fleet

$$P_{electric} = \frac{V_{electric}}{V_{total}} 100, \quad (16)$$

Where: $P_{electric}$ – percentage of electric vehicles;

$V_{electric}$ – number of electric vehicles.

This indicator reflects the level of sustainability within the transportation system. A higher proportion of electric vehicles signals progress in adopting cleaner technologies, which are advantageous for the environment and public health, and may lower long-term operational expenses. A lower share signifies ongoing dependence on conventional internal combustion vehicles and underscores the necessity for more investment in electrification and pollution mitigation.

Social and organizational indicators

6.1. Employee satisfaction

$$ES = \frac{\sum_{i=1}^M S_i}{M}, \quad (17)$$

Where: ES – employee satisfaction score;

S_i – satisfaction score given by employee i ;

M – total number of surveyed employees.

This metric assesses employees' contentment regarding their workplace environment, employment terms, remuneration, and overall organizational governance. It is evaluated using surveys or interviews, scored on a scale of, for example, 1–5 or 1–10 to capture employees' perceptions of their workplace experiences.

6.2. Staff training

$$TH = \frac{H_{total}}{N_{employees}}, \quad (h), \quad (18)$$

Where: TH – training hours per employee;

H_{total} – total number of training hours;

$N_{employees}$ – number of employees.

Demonstrates the extent of people training, crucial for professional development and service efficacy. Quantified as the mean training hours per employee.

Innovation and technological development indicators

7.1. Integration of mobile platforms

$$MBS = \frac{N_{mobile}}{N_{total}}, \quad (19)$$

Where: N_{mobile} – number of tickets purchased via mobile applications (e.g., apps, QR codes, other digital methods);

N_{total} – total number of tickets sold.

This indicator assesses the degree of integration of mobile platforms into the transport system, reflected in the proportion of services or routes employing mobile solutions or the ratio of passengers utilizing these platforms.

7.2. Development of intelligent transport systems

$$ITS_{AR} = \frac{N_{ITS}}{N_{total}} 100, \quad (20)$$

Where: ITS_{AR} – percentage of vehicles equipped with intelligent transport systems;

N_{ITS} – number of vehicles equipped with intelligent transport systems (e.g., GPS, smart stops, onboard computers, IoT sensors);

N_{total} – total number of vehicles.

This formula indicates the degree of development and implementation of intelligent transport systems, including traffic management, navigation, safety technologies, and operational optimization. It is quantified as the percentage of integrated solutions for intelligent transport systems inside the transport infrastructure or the extent of operational automation.

The fourth phase of KPI system development involves the periodic assessment and adaptation of indicators in reaction to alterations in external conditions and market dynamics. This phase is directly reliant on several challenges, including adapting to a rapidly changing market, financial constraints, infrastructure requirements, technological innovations, and other factors.

The urban transportation services market is continually evolving, with emerging rivals such as taxi services and ride-sharing platforms intensifying competition. This necessitates the adaptation of KPIs to accurately represent these changes and assess the performance of public transport services in a competitive environment.

The growing transition toward eco-friendly and efficient vehicles necessitates significant investment. Securing the necessary financial resources for these enhancements requires careful planning, which can be hindered by budget limitations and reliance on public funding.

Infrastructure conditions and technological innovations require vigilant monitoring, with proactive adjustments to KPIs as needed.

An integrated effectiveness index (IE) may be utilized for a comprehensive performance assessment, amalgamating the diverse KPI categories.

$$IE = w_1 Financial + w_2 Operational + w_3 Quality + w_4 Safety + w_5 Ecological + w_6 Social + w_7 Innovation, \quad (21)$$

where $w_1, w_2, w_3, w_4, w_5, w_6, w_7$ are coefficients that reflect the relative importance of each category of indicators.

The coefficients $w_1, w_2, w_3, w_4, w_5, w_6, w_7$ of the integrated effectiveness index are determined by the strategic objectives of Municipal Transport Ruse and the priorities established by the organization or municipality. The subsequent recommendations are based on common practices and the significance of various sectors in urban transportation, as well as on researched expert opinion about the strategic objectives of the transport company and the municipality for 2024.

Financial indicators, $w_1=0.2$. Financial stability is important but not paramount. It is essential to maintain sustainable budgets and fund innovation while balancing social and ecological objectives.

Operational indications, $w_2=0.2$. Operational efficiency is essential, as it encompasses the timeliness of transportation, capacity management, and route optimization, thus guaranteeing service quality and resource efficiency.

Quality of service, $w_3=0.2$. Service quality must be prioritized, as passenger satisfaction and comfort are essential for the success of public transport.

Safety, $w_4=0.15$: Safety is fundamental and serves as a basic prerequisite, without which the other elements cannot be efficiently executed. It should not be undervalued.

Ecological indicators, $w_5=0.1$. Environmental sustainability is a crucial factor, particularly in the context of reducing carbon emissions and adopting green technology, although it may be less urgent in the short term than financial or operational concerns, unless it is a municipal priority of strategic importance.

Social indicators, $w_6=0.1$. Social inclusion encompasses the accessibility of transportation services for various social groups, including vulnerable ones, as well as the entitlement to complimentary or discounted fares for specific demographics such as retirees and students. This is crucial for developing equitable transportation, although it holds diminished significance for evaluating effectiveness.

Innovation, $w_7=0.05$. Technological innovation, such as the adoption of new technologies, electric buses, and the digitalization of payment systems, is essential for long-term development; however, it is less crucial in the short term unless explicitly prioritized by the municipality.

If Municipal Transport Ruse's strategic aims shift towards emissions reduction and innovation, the coefficients can be modified to prioritize ecological and innovation-related KPIs. If cost optimization and revenue growth are emphasized, financial and operational KPIs may be weighted more heavily.

3. RESULTS AND DISCUSSION

The key performance indicator values for 2024 were examined for Municipal Transport Ruse Ltd according to the proposed methodology (Table 2).

The analysis of the data in Table 2 reveals both accomplishments and areas requiring targeted improvement.

The presented financial indicators' values demonstrate that the urban transport system operates with relative financial sustainability. Ticket, pass, and compensation revenues amount to BGN 6,084,302, and the profit per passenger is positive (BGN 0.2951), reflecting baseline efficiency. However, the cost per kilometer (BGN 4.67) is relatively high, and the share of subsidies in total revenue constitutes merely 24%. This is below common benchmarks observed in good European practices, suggesting a considerable financial strain on passengers and/or limited capacity for service enhancement and modernization. In conclusion, while financial results appear stable, there is a need for strategic reevaluation of funding mechanisms, including augmentation of subsidy levels and the optimization of transport expenditures.

Operational indicators demonstrate a high level of reliability and efficiency within the urban transportation system. Route occupancy is 0.96 passengers/km, indicating balance, while both punctuality and route coverage are excellent, with 98% of trips adhering to the timetable and 98% of routes being completely served. The lack of service frequency data constrains the evaluation of passenger convenience. The system exhibits effective operational organization and resilience.

Quality indicators of the urban transport display a good overall level of service. Passenger satisfaction is 68%, which is acceptable but leaves room for improvement. Cleanliness and comfort are highly rated (88%), and all received complaints have been addressed (100%), reflecting a responsible approach to feedback. In summary, the service is perceived positively, though there is potential to enhance passenger satisfaction further.

Safety indicators reflect a very high safety standard. The number of incidents is extremely low—just 0.000074%, indicating that vehicles are safe for passengers. Furthermore, 100% of vehicles undergo regular safety checks, ensuring compliance with safety standards, which reflects effective safety management and a commitment to risk prevention.

Environmental indicators demonstrate a strong commitment to the sustainable development of urban transport. CO₂ emissions are relatively low (11,665 kg), and energy efficiency is good, though further improvement is possible. Most notably, the substantial share of electric vehicles in the fleet (73%) markedly reduces pollution and enhances system sustainability. Despite positive outcomes, continued efforts should focus on further reducing emissions and improving energy efficiency.

Table 2

Key Performance Indicators for 2024 – Municipal Urban Public Transport Company: Municipal Transport Ruse Ltd

Primary Indicator Categories	N	Key Performance Indicators (KPI)	Values
1. <i>Financial</i>	1.1.	R_{ticket} , Total revenue from tickets, passes, and compensations	6,084,302 BGN
	1.2.	C_{km} , Cost per kilometer of transportation	4.67 BGN
	1.3.	$P_{passenger}$, Net profit per passenger	0.2951 BGN
	1.4.	$P_{subsidy}$, Percentage of subsidies	24%
2. <i>Operational</i>	2.1.	N_m , Route occupancy	0.96
	2.2.	$T_{frequency}$, Average waiting time per passenger	n/a
	2.3.	P_n , Percentage of on-time vehicles	98%
	2.4.	$P_m\ covered$, Percentage of fully covered routes	98%
3. <i>Quality</i>	3.1.	$U_{pasenger}$, Average passenger satisfaction score	68%
	3.2.	$I_{cleanliness}$, Average cleanliness index	88%
	3.3.	$P_{complaint}$, Percentage of complaints resolved	100%
4. <i>Safety</i>	4.1.	$P_{incident}$, Percentage of incidents	0.000074%
	4.2.	$P_{checked}$, Percentage of vehicles inspected for safety	100%
5. <i>Ecological</i>	5.1.	E_{CO2} , Total CO ₂ emissions	11,665 kg
	5.2.	EE, Energy efficiency	0.48 l/km I 1.60 kWh/km (9638 kJ/km)*, [23] EE: 2.08 km/l, 0.625km/kWh
	5.3.	$P_{electric}$, Percentage of electric vehicles	73%
6. <i>Social</i>	6.1.	ES , Employee satisfaction score	n/a
	6.2.	TH , Training hours per employee	10
7. <i>Innovation</i>	7.1.	MBS , Integration of mobile platforms	0
	7.2.	ITS_{AR} , Percentage of vehicles equipped with intelligent transport systems	100%

* Energy consumption kWh(l)/km

Social indicators show that staff training data is available (10 hours per employee), indicating efforts toward workforce upskilling. However, a lack of data on employee satisfaction limits insight into staff motivation and workplace climate.

Innovation indicators demonstrate good progress in the deployment of intelligent transport systems (100%), improving efficiency and traffic management. However, the absence of mobile platform integration (0%) restricts enhancements in user experience and passenger convenience.

4. CONCLUSIONS

The analysis of key performance indicators for monitoring efficiency within the urban passenger transport company “Municipal Transport Ruse” Ltd. carried out in this study has led to several key findings, recommendations, and perspectives for future development. These findings support the optimization of the current public transport services in Ruse and help define directions for long-term sustainable development and innovation in the transport sector.

The seven identified key indicator categories—financial, operational, quality, safety, ecological, social and organizational, and innovation and technology development—are based on the existing business plan of the transport company. Given that the strategic objectives of the company largely align with those of other transport operators countrywide, this KPI system can be successfully applied by other public transport providers. The development and execution of a KPI monitoring system is essential for enhancing the management of urban transport networks and optimizing operational processes.

If sustainable development is to be achieved in public transport, ongoing efforts must focus on integrating innovative technologies, expanding data networks, complying with European and global

standards, promoting public-private partnerships, and supporting research initiatives aimed at implementing new technologies and policies in the transport sector.

The data analysis for Municipal Transport Ruse Ltd. indicates strong performance in many areas while also identifying areas that require attention and enhancement. Financial outcomes are stable, but there is a need for increased subsidies and cost optimization. Although operational indicators demonstrate high reliability and effectiveness, a lack of service frequency data limits comprehensive evaluation. Service quality is generally good, with room for improvement in passenger satisfaction. Safety levels are exceptionally high, and environmental indicators confirm a commitment to sustainability. Social and innovation indicators reflect investments in staff training and advancements in intelligent transport systems; however, there remains a need to develop mobile platforms for improved user experience.

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