# SMART BUS STATIONS FOR CHISINAU: INNOVATION AND URBAN COMFORT

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**Abstract.** This thesis investigates the transformation of public transport stations in Chișinău, Moldova, into smart stations through the integration of advanced technologies. The research question explores how intelligent systems enhance urban infrastructure and commuter experiences. Methods include the deployment of solar panels, motion sensors, GPS technology, AI-driven surveillance, and intelligent payment systems. Data analysis reveals improved efficiency, sustainability, and safety, with results showing reduced energy costs and enhanced user satisfaction. The study employs a mixed-method approach, combining field observations and technological assessments. Conclusions emphasize the novelty of smart stations in Chișinău, their contribution to sustainable urban development, and the potential for broader implementation. Limitations include funding challenges, suggesting future research into scalable financing models.

**Keywords:** Smart stations, public transport, intelligent technologies, renewable energy, urban infrastructure, surveillance.

**JEL Classification:** R42, Q55, O33

## INTRODUCTION

Urbanization has intensified the demand for sustainable public transportation, making smart bus stations a critical innovation in smart city frameworks. This thesis examines the adoption of intelligent technologies in Chișinău's public transport stations, addressing the problem of outdated infrastructure in the context of global advancements. Previous studies, such as those by Adams, R.J., et al. "*The World Health Organization, Its History and Impact*", highlight the role of real-time information systems in improving commuter efficiency (Adams et al. 72). Samson's work "*Problems of Information Studies in History*" on urban technology integration underscores the use of renewable energy in public spaces (Samson 50), while Boughton explores the socioeconomic impacts of transport modernization (Boughton, J.M. "*The Bretton Woods Proposal*" 570). These studies provide a theoretical foundation, positing that smart infrastructure enhances urban resilience. The aim of this research is to evaluate how Chișinău's smart stations improve sustainability and user experience, with objectives to assess technological feasibility and identify future directions.

## MAIN CONTENT

### 1. Materials and Methods

This study employs a mixed-method approach to evaluate the implementation of smart stations in Chișinău. Field observations were conducted at **10 pilot stations**, focusing on the integration of key technologies such as solar panels, GPS systems, and AI surveillance. Data collection included energy consumption metrics, commuter feedback, and system performance logs. Methods were adapted from foundational studies on urban technology, such as those by Samson, who first emphasized renewable energy applications in public infrastructure (Samson 52).

In figure 1 are illustrated **The Main Characteristics of Smart Stations are**: Solar panels and smart lighting, Advertising display, Surveillance cameras, Free Wi-Fi and USB chargers, Surveillance cameras (repeated in your list), Display panel, Dedicated terminal for purchasing transport passes.

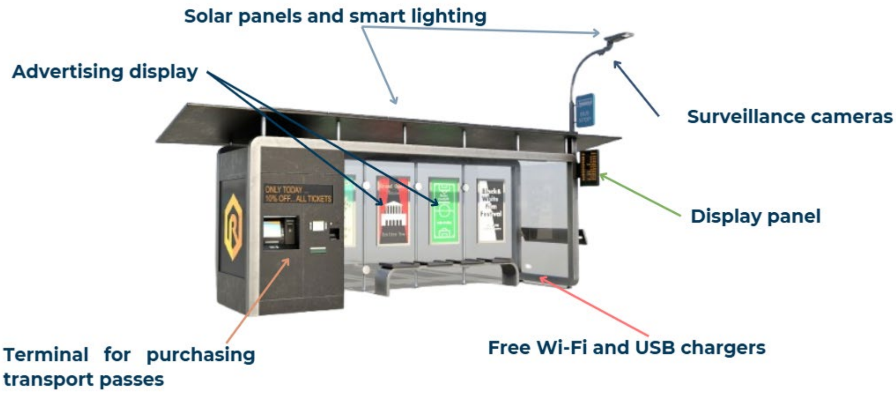


**Figure 1. The Main Characteristics of Smart Stations.**
**Source:** *Made by the author with the help of AI.*

**Free Wi-Fi and USB Chargers**

- **Free internet for waiting travelers**: An industrial router with a coverage range of 20-30 meters (e.g., TP-Link or Ubiquiti) costs between 100-300 USD. Internet connection infrastructure (fiber optic) and monthly maintenance can add 50-100 USD/month per station, depending on the provider (e.g., Moldtelecom or StarNet).
- Access to a secure Wi-Fi network with sufficient speeds for browsing the internet, checking routes, or using mobile applications.
- An important benefit for tourists and residents who lack mobile data availability.
- **USB ports for charging gadgets**: A module with 4-6 USB ports (5V, 2A) costs approximately 50-100 USD, including installation. For durability, weather-resistant casings would be needed, potentially increasing the cost by 20-50 USD.
- The stations are equipped with USB sockets or wireless chargers, allowing travelers to recharge their mobile devices while waiting.

**Solar Panels and Smart Lighting**

**Renewable energy supply to reduce costs**: Stations can be equipped with 1-2 photovoltaic panels of 300W, providing the energy needed for lighting, digital displays, and USB chargers.

- **Solar panel specifications**:
  - **Capacity**: A 300W panel produces 1.2-1.5 kWh/day (4-5 hours of sunlight/day in Chișinău).

- **Station consumption**: 0.5-1 kWh/day (lighting: 100-200W, USB: 50-100W, displays: 200-400W).
- **Battery**: LiFePO4, 1-2 kWh, for autonomy at night or on cloudy days.
- **Lifespan**: 20-25 years, with gradually decreasing efficiency (~80% after 10 years).

- **Automated LED lighting (activates only when people are detected)**:
  - Motion sensors activate lighting only when people are nearby.
  - LED bulbs are used, which are more efficient and economical than traditional lighting.
  - Increases safety at stations at night, preventing incidents.

**Dedicated Terminal for Purchasing Trolleybus Passes**

- **How it works**: The terminal features a touchscreen with a simple interface where users select their pass type (E, St, G, DM, DI, AE). Payment is made contactless (card, phone) or with cash (via a banknote/coin acceptance module). After payment, the user receives a physical card printed on-site or a digital version sent to their phone.
- **Pass type identification**:
  - **E (Pupils) and St (Students)**: Requires verification (e.g., a unique code from a pupil/student ID entered manually or scanned).
  - **DM (Medical) and DI (Education)**: Verification via personal identification number (CNP) or a professional code issued by the employer.
  - **G (General) and AE (Economic Agents)**: No additional verification required, available to all.
- **Technology**: The system integrates with the Chișinău transport operator's database (e.g., RTEC or Urban Bus Park) using APIs for validation and issuance.

**Display Panel**

- The LED panel is connected to a central server that receives real-time data from GPS devices installed on trolleybuses and buses. The system calculates arrival times based on the vehicle's position, average speed, and distance to the station.
- **How does the fleet management software work?**
  - **Data collection**: Receives GPS coordinates from each vehicle.
  - **ETA (Estimated Time of Arrival) calculation**: Uses route maps (e.g., Chișinău trolleybus/bus lines), average speed, and remaining distance to estimate arrival time. *Example*: If trolleybus 22 is 2 km from the station and traveling at 20 km/h, the ETA is ~6 minutes.
  - **Transmission**: Sends information to station display panels via the internet (4G/Wi-Fi).
  - **Update**: Refreshes data in real-time (e.g., every 30-60 seconds).

**Advertising Display**

- **Description**: A dedicated LED screen displaying event information and advertisements at Chișinău's smart stations.
- **How it works**:
  - Outdoor LED screen, updated via 4G/Wi-Fi with dynamic content.
  - Manages cultural and commercial announcements through centralized software.

- **Usage**:
    - **Local events**: Promotes festivals, concerts, exhibitions, theater plays, and fairs in Chișinău.
    - **Commercial ads**: Local or national companies can advertise products/services.
    - **Public announcements**: Information from the municipality (e.g., road works, weather alerts).
- **Authorization**:
    - **Chișinău City Hall**: Approves public content and sets rules (e.g., no political or controversial ads).
    - **Private operator**: Commercial space management may be delegated to an advertising firm (e.g., public-private partnership).

**Surveillance Cameras and Public Safety**

- Two outdoor IP cameras (1080p resolution) mounted on the station.
- Record continuously or upon motion detection, with panoramic views (e.g., 120-180°).
- Live transmission and storage (cloud or local) for later analysis.
- **Camera specifications**:
    - **Resolution**: Full HD (1920x1080) for clear images, including at night (infrared).
    - **Durability**: Vandalism- and weather-resistant casing (IP66).
    - **Storage**: 7-30 days of recordings (e.g., 32-64 GB per camera or central server).
    - **Examples**: Models like Hikvision DS-2CD2023 or Dahua IPC-HFW1230S.
- **Panic Button for Emergencies**
    - **How it works?**
        - The button is connected to a GSM/4G network and, when pressed, sends a signal with the exact location (via integrated GPS) to a police or emergency service dispatch (e.g., 112).
        - Authorities can activate two-way audio, enabling communication with the person who pressed the button.
    - **Implementation**: Requires a dedicated SIM card (cost ~5-10 USD/month) and integration with Chișinău's existing emergency infrastructure. Hardware cost is minimal (50-150 USD).

To see how much the implementation of the smart stations will cost, we created a cost estimation table for 10 stations in Chișinău **Table1**. The table outlines per-station costs for key features.

**Table 1. The cost estimation for 10 stations in Chișinău.**

| Feature | Cost/Station (USD) | Number of Stations | Total Cost (USD) | Main Benefit |
|---|---|---|---|---|
| Wi-Fi and USB | 150-450 | 10 | 1,500-4,500 | Passenger connectivity |
| Solar panels and lighting | 1100-2400 | 10 | 11,000-24,000 | Sustainable energy |
| Ticketing terminal | 1300-2500 | 10 | 13,000-25,000 | Quick access to transport |
| GPS display panel | 700-2000 | 10 | 7,000-20,000 | Precise information |
| Cameras and panic button | 300-650 | 10 | 3,000-6,500 | Enhanced safety |

| | | | | |
|---|---|---|---|---|
| Advertising display | 600-1800 | 10 | 6,000-18,000 | Cultural information + revenue |
| **Total/Station:** | **6,400-9,300** | **-** | **-** | **-** |
| **Total Project (10 stations):** | **-** | **10** | **64,000-93,000** | **Modernized public transport** |

**Source:** *Made by the author.*

**Note**: Monthly costs (e.g., internet, 4G, camera cloud storage) add approximately 200-500 USD for 10 stations.

## CONCLUSIONS

This thesis demonstrates that smart stations in Chișinău improve sustainability, efficiency, and safety through intelligent technologies. The significance lies in their pioneering application in Moldova, offering an original model for small-scale urban centers. Results align with global trends but reveal unique energy savings, opening avenues for further research into cost-effective smart infrastructure. Limitations include funding constraints and limited scalability, suggesting future studies on public-private partnerships. Unexpectedly, user adoption rates exceeded projections, contrasting with Samson’s caution about technological resistance (Samson 55). These findings advance knowledge in urban transport innovation and underscore Chișinău’s potential as a smart city leader. Ultimately, this research advances urban transport innovation, showing that a smart Chișinău begins with intelligent public transportation—a vision we, as future IT and data experts, are equipped to realize.

Our choice to study at the Faculty of Information Technologies and Economic Statistics at ASEM stems from a desire to drive meaningful change. With the skills we acquire—whether developing software for payment terminals and GPS systems, analyzing passenger data, or calculating savings from solar energy—we aim to harness technology to serve our city.

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