→ Insights

Improving Energy Efficiency of Urban Rail Systems

→ Bahia, Brazil

International Association of Public Transport (UITP)
Rue Sainte-Marie, 6 | B-1080 Brussels | Belgium

Tel: +32 2 673 61 00
info@uitp.org
www.uitp.org

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Glossary

→ **CAPEX** – Capital expenses.

→ **EMS** – Energy management system.

→ **HVAC** - Heat and ventilation air conditioning.

→ **KPI** – Key performance indicators.

→ **kWh** – Kilowatt hour.

→ **LED** – Light emitting diode.

→ **MWh** – Megawatt hour.

→ **OPEX** – Operating expenses.

→ **R&D** – Research & development.

→ **TCO** – Total cost of ownership.

→ **UITP** – International Association of Public Transport.

→ **UITP VEIC** – Vehicles and Equipment Industry Committee.

→ **VDV** – Association of German Transport Companies (Verband Deutscher Verkehrsunternehmen).

Introduction

The volatility of global energy markets since 2021 has had a profound impact on urban rail operations. The sharp rise in electricity prices, particularly in 2022, put unexpected pressure on the budgets of metros, trams, and suburban rail systems. While prices have stabilised somewhat, energy costs are expected to remain elevated for the foreseeable future, particularly in Europe. For public transport agencies with fixed budgets and limited ability to increase fares, improving energy efficiency has shifted from a sustainability goal to an operational necessity.

At the same time, the environmental imperative has grown stronger. Urban rail systems are inherently more energy-efficient than private vehicles, but they still consume considerable power. Reducing energy consumption not only lowers operating costs but also supports broader climate objectives. In a recent global survey, over 70% of operators reported having formal energy efficiency targets, often mandated by national or local authorities.

This publication, developed by the UITP VEI Working Group, provides practical guidance for improving energy performance in urban rail. Drawing from an international survey of operators and global best practices, it presents both short-term (low or no CAPEX) measures and long-term strategies that require greater investment but offer substantial efficiency gains.

The following chapters explore how operators monitor energy, define key performance indicators (KPIs), manage energy costs and implement technical and operational improvements. This Insight publication also highlights challenges in procurement and funding, and provides actionable recommendations for policy-makers and transit agencies alike.

Improving energy efficiency in urban rail is no longer optional. It is essential for financial resilience and environmental leadership. With the right strategies, public transport systems can deliver the same high-quality mobility with significantly lower energy input. The time to act is now.

Oslo, Norway ←
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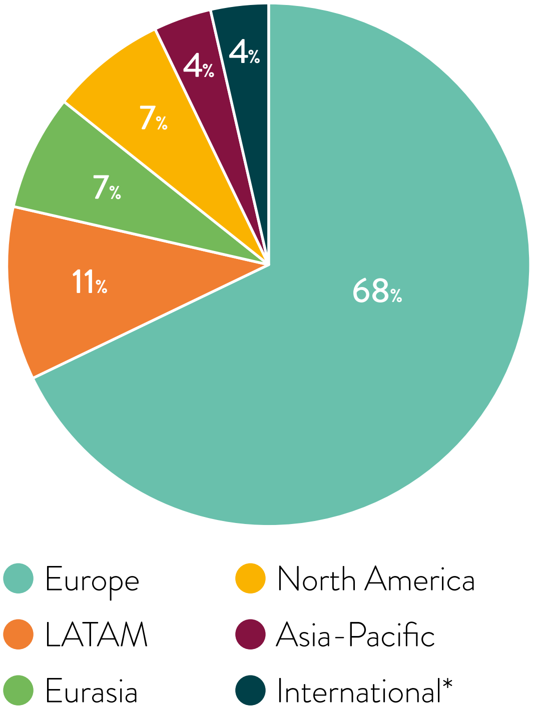
Approach: Context and Motivation

To develop this publication, the UITP VEI Committee's Rail Energy Efficiency Working Group followed a collaborative, evidence-based approach. At the heart of this process was an international survey conducted in late 2024. The survey was designed to gather both quantitative data and qualitative insights from urban rail operators and infrastructure managers worldwide. It explored key themes such as energy monitoring practices, current and planned efficiency measures, procurement strategies and perceived barriers to progress.

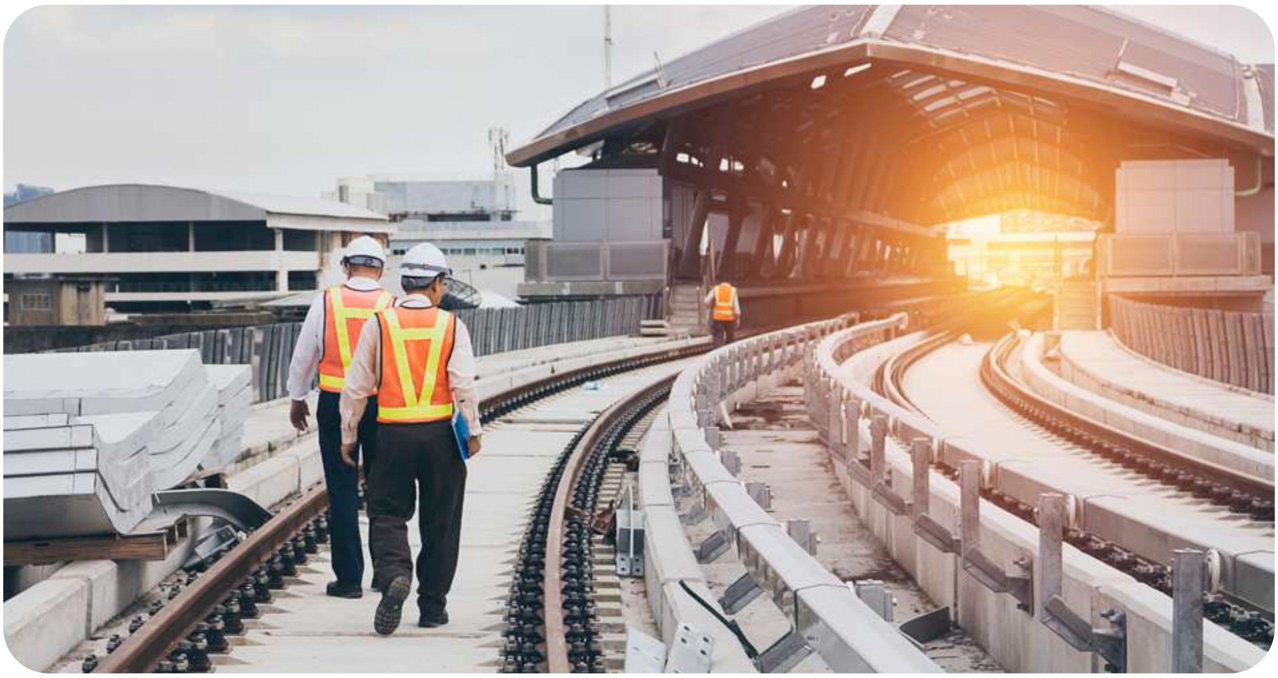
Figure 1: Respondents geographical scope (31 responses)



In total, 31 responses were received from a pool of 185 invited stakeholders, representing a wide cross-section of metro, light rail, and suburban rail networks across all continents. The diversity of respondents, including both public and private operators of different sizes, provided a valuable snapshot of current practices, challenges and priorities in the field. While not statistically exhaustive, the survey results offer meaningful insights into common trends and emerging needs across the industry.

*'International' means that the company is presented in more than one region.

→ Los Angeles, USA. © LA Metro



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70%+
have formal energy efficiency goals

~60%
say more political backing required

The objectives of the survey were twofold. The first is to identify the key areas where action on energy efficiency is most needed and impactful. The second is to validate the strategic direction of the working group's planned outputs. In short, the survey served as a reality check to ensure that the focus areas of this publication align with the real-world concerns of operators.

In addition to the survey, the working group conducted desk research and drew upon recent European and national studies, including initiatives studies, including Europe's rail overview report "Energy saving in rail: Consumption assessment, efficiency improvement and saving strategies"[1], 2024, and the and the 2022 VDV position "Short-term energy-saving measures for bus and rail companies"[2] that recently addressed the topic. Expert consultations and internal knowledge sharing among members further enriched the findings. Selected best practices and case studies are highlighted throughout this document to show practical applications of the concepts discussed.

The survey provided insights into the state of policy from formal efficiency goals and the need for political backing, whether in the form of incentives, rules, or special funding. These insights informed the recommendations made in the following chapters, guaranteed to be both technically sound and operationally relevant thanks to the combined methodology of survey, research, and expert exchange. These sections examine how authorities and operators track their energy consumption, establish performance metrics and put organisational and technical efficiency-boosting measures into place.

Feedback and Political Framework

A strong and coherent political framework plays a pivotal role in enabling energy efficiency in urban rail systems. The findings from the UITP VEI survey reveal that while many operators are already operating under formal efficiency targets, there is a widespread demand for more robust and supportive policy environments.

Over 70% of respondents indicated they are subject to binding energy efficiency goals which, typically, are set by national governments, regional authorities or defined through contractual service agreements. These targets often align with broader climate action plans and reflect the growing expectation that public transport systems actively contribute to achieving decarbonisation objectives.

However, meeting these targets in practice is far from straightforward. Approximately 60% of operators stated that additional political support is needed to advance their efforts effectively. This highlights a gap between the existence of targets and the availability of enabling frameworks such as funding instruments, regulatory guidance or incentive programmes.

Operators identified several areas where political and regulatory intervention could significantly accelerate progress:

- → Investment subsidies for rolling stock upgrades, energy monitoring technologies and infrastructure modernisation.
- → Mandatory efficiency standards in public procurement, including the requirement to consider energy KPIs in tenders.
- → Market-based incentives, such as energy-saving bonuses, access to emissions trading mechanisms or the possibility to feed recovered energy back into the grid.

Figure 2: Political frameworks for energy efficiency in urban rail

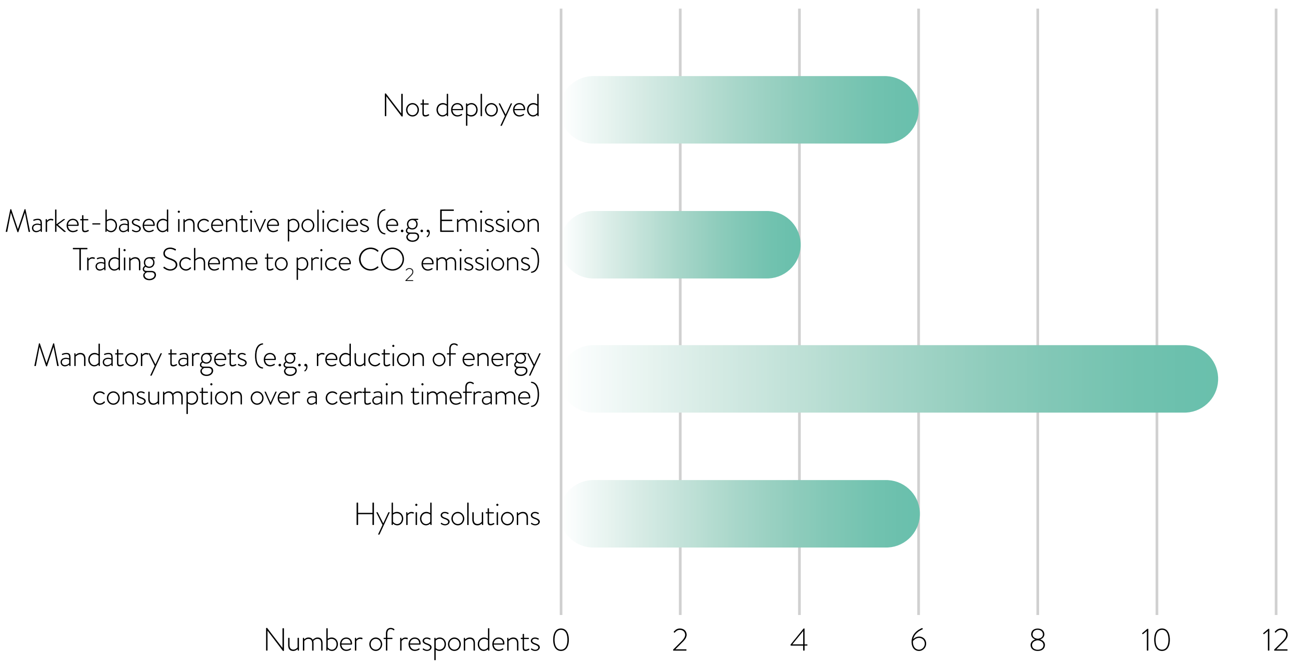


Figure 3: Additional political framework conditions for energy efficiency in urban rail

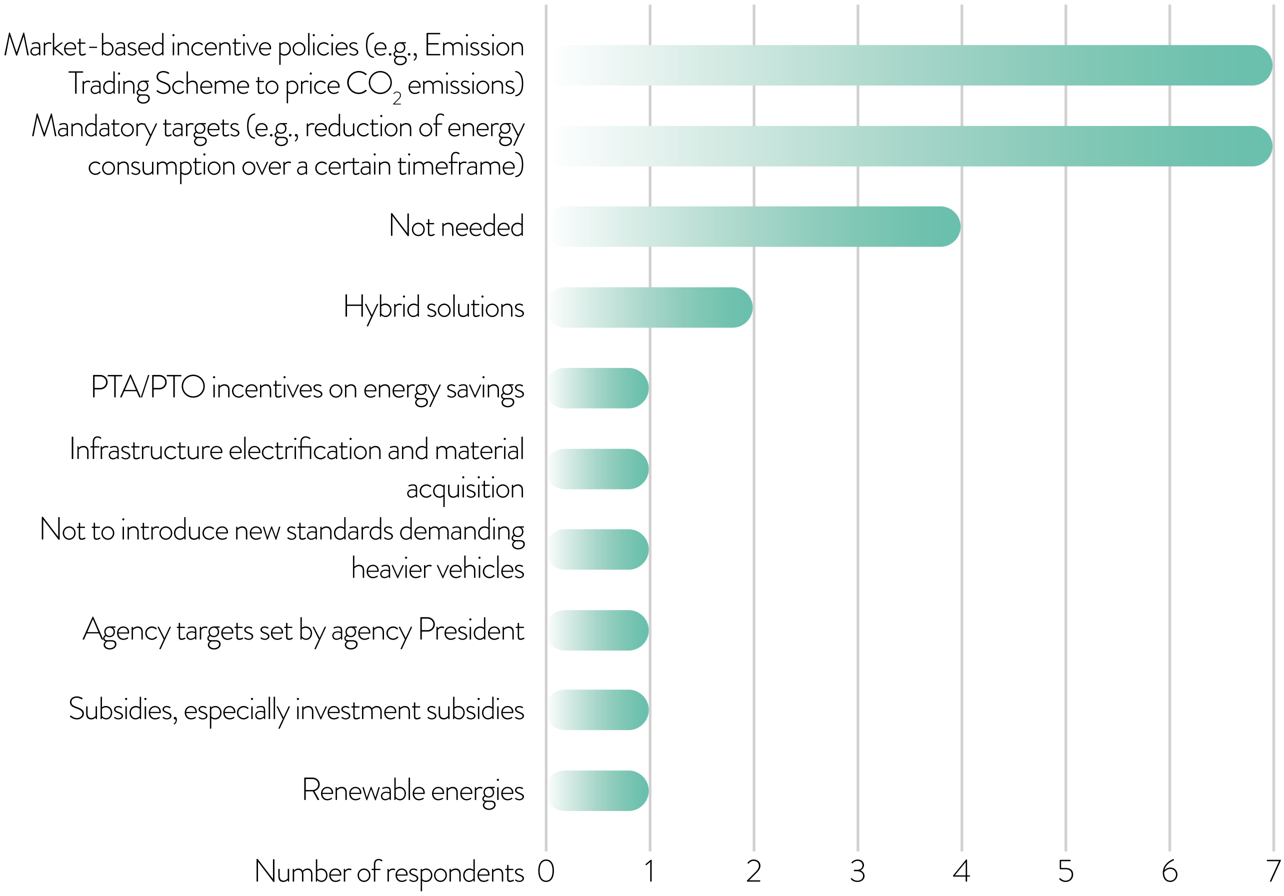


Figure 3 illustrates that while the majority of operators already work under mandatory energy efficiency targets, a substantial portion also call for additional support and policy development. This reflects a shared concern that existing frameworks are not yet sufficient to enable impactful and scalable efficiency measures.

The responses highlight a key challenge in many jurisdictions in that operators are increasingly expected to deliver energy savings, yet often lack the regulatory and financial tools to do so effectively.

To drive systemic and widespread improvements, policy-makers must align climate ambitions with implementation pathways. This includes providing multi-year investment planning certainty, integrating energy performance into transport funding criteria and actively incentivising innovation in public procurement.

Without coordinated support, especially at national and European level, energy efficiency remains dependent on the initiative and creativity of individual cities or operators.

As the next chapters will show, urban rail systems already have the tools to reduce energy consumption across vehicles, operations and infrastructure. But unlocking this full potential depends on a political framework that actively empowers the sector to act.

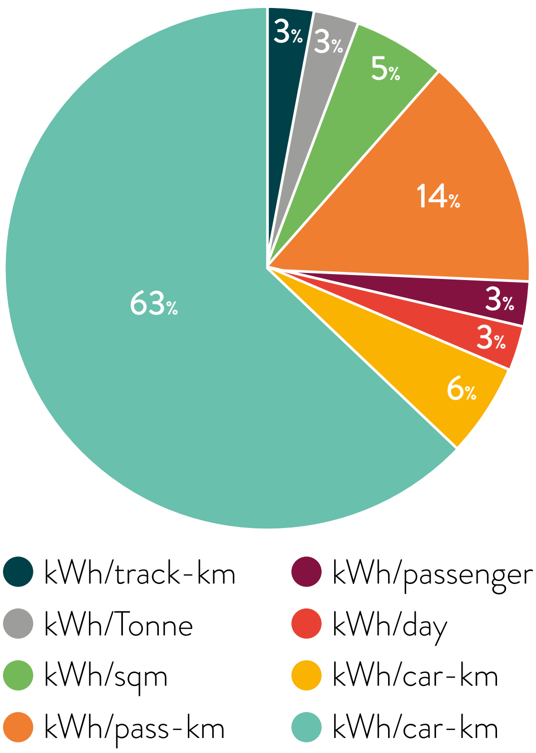
→ Oslo, Norway. © Ruter/Hampus Lundgren

Monitoring and Key Performance Indicators

Effective energy management starts with measurement. The UITP VEI survey confirmed that most urban rail operators monitor their energy consumption, typically at the traction substation level. This provides a system-wide overview of how much energy is drawn from the grid and forms the basis for managing usage.

However, granular data is essential to drive real improvements. Many operators now track energy performance with standardised indicators, the most common being kilowatt hours per car-kilometre (kWh/car-km). This KPI allows for meaningful efficiency comparisons across time and systems, independent of service volume. Some agencies also use kWh per passenger-kilometre, but such ridership-based metrics are less common due to fluctuations outside operator control.

Figure 4: Energy performance indicators



The graphic on the left summarises the different energy performance indicators reported by survey respondents. The dominant metric, used by a majority of operators, is kilowatt-hours per car-kilometre (kWh/car-km), which offers a normalised view of energy consumption relative to service volume. A smaller number of networks report using kWh per passenger-kilometre or per seat-km, typically in external reporting or sustainability frameworks. These alternative KPIs link energy use to ridership or capacity, but are less commonly used for internal operations, due to variability in occupancy rates. This confirms that kWh/car-km remains the 'workhorse' KPI for operational benchmarking and energy efficiency tracking in rail systems.

Establishing standardised definitions and wider adoption of this metric would also enable better cross-network benchmarking and target-setting across the industry.

While most networks monitor traction energy, only a minority measure energy use at the level of individual trains or components. A growing number of systems are introducing onboard meters and energy data loggers, enabling detailed tracking and even driver-specific feedback. It is worth underlining that despite the proven impact of driving style on energy consumption, up to 15–20%, only around half of operators actively assess or manage it.

In short, robust monitoring is the foundation of any energy efficiency strategy. As technology becomes more affordable, the trend is clearly towards more granular, real-time energy management and those who invest in it will be in a better position to cut costs, reduce emissions, and justify future improvements.

Infrastructure energy (such as stations, depots) is also monitored though practices vary. Some agencies employ building automation systems to control lighting and HVAC in real-time, optimising energy usage based on demand. Others still rely on aggregate utility data, which lacks the resolution needed to identify inefficiencies.

One recurring theme in the survey was the lack of data granularity and usability. Monthly utility bills, delayed access to consumption records or lack of integration between systems limit the ability to act on insights. Leading operators are therefore investing in advanced metering infrastructure and real-time monitoring systems that allow for detailed energy profiling.

Besides intensity metrics such as kWh/car-km, a comprehensive KPI framework may include:

→ Boundaries to define the total energy consumption (MWh).

→ Total energy consumption (MWh).

→ Building/station energy KPIs (kWh/m^2 or kWh/m^3).

→ Energy cost as a share of OPEX.

→ Regenerative braking recovery rate.

Ideally, the selected KPI must allow the maintenance or reliability impacts of energy efficiency measures to be quantified.

Lastly, harmonisation of KPIs across networks would enable meaningful benchmarking. Many respondents expressed interest in peer comparisons, suggesting that consistent, standardised metrics could foster learning and performance improvement across the sector.

Energy Cost Structures and Financial Drivers

How an urban rail operator is billed for electricity has a direct impact on energy management strategies. The UITP VEI survey revealed that **contracted power charges** (fixed fees for guaranteed capacity) are the dominant cost component in most operators' energy bills. These fees are paid regardless of actual energy consumption and make **peak demand management** as important as overall efficiency.

Key components of energy bills:

- Contracted capacity (for example, 50 MW flat fee).
- Variable energy use (kWh-based).
- Peak demand surcharges.
- Penalties for exceeding threshold.
- Occasional incentives, such as off-peak bonuses or power factor reward.

As shown in the survey, **43% of operators face explicit peak demand charges and around 20% incur penalties for exceeding limits.** However, incentives for efficient behaviour remain rare. Less than one-third of respondents benefit from any financial rewards for saving energy or improving power quality.

→ Seattle, USA

Warsaw, Poland
© Metro Warszawskie

The implications are clear:

- **Reducing kWh alone may yield limited savings** if peak demand stays constant.
- **Peak shaving strategies,** such as staggering train departures or using wayside energy storage, are gaining attention.
- **Lack of incentives** means that most efficiency investments must justify themselves through cost avoidance, not bonus payments.

One illustrative finding is that even **operators who reduce their energy use by 10% may see only marginal bill reductions if their contracted capacity remains unchanged.** Conversely, sustained demand reduction can justify contract renegotiation and unlock further savings in future billing periods.

Some operators reported engaging in time-of-use optimisation, shifting energy-intensive tasks to off-peak periods where tariffs are lower, though this remains uncommon due to the absence of dynamic pricing in many regions.

Additionally, while regenerative braking is increasingly adopted, **less than 20% of respondents are able to resell recovered energy to the grid.** In most cases, energy is reinjected into the rail network for immediate reuse. This is an efficient solution, but one that lacks financial return unless specific metering and feed-in policies are in place.

Finally, transparency is critical. Some operators indicated difficulties understanding how their energy bills are calculated. Simple measures, such as power factor correction or engaging with suppliers to clarify tariff structures, can help reduce costs and improve investment planning.

In conclusion, a clear understanding of energy cost structures is essential to make sound energy efficiency decisions. Operators must evaluate each measure not only by how much energy it saves, but whether it reduces peak demand, avoids penalties or opens the door to contract optimisation. Only with this holistic view can the full financial value of efficiency be achieved.

Challenges and Barriers

While the technology potential to improve energy efficiency in urban rail is well understood, implementation often encounters a range of practical challenges. The UITP VEI survey identified two dominant barriers faced by operators:

- → Costs linked to the need to wait until the next RS replacement cycle (10 mentions).
- → Poor data quality and low granularity: availability of data monitoring (6 mentions).

Other issues mentioned at least once were:

- → Mandate to go for a low price.
- → Deadlines.
- → Efficiency-comfort balance.
- → Maintaining existing levels of operation and safety.

Cost and Investment Cycles

Many efficiency measures, such as onboard energy storage or new rolling stock, can only be implemented during major renewal cycles. Tight public budgets and a focus on immediate service delivery make it difficult to justify upfront investments, even when long-term savings are evident.

The most frequently mentioned obstacle was cost, especially in relation to capital-intensive upgrades.

Furthermore, procurement rules in many regions prioritise the lowest bid, making it hard to select more energy-efficient options if they are not the cheapest upfront. Unless total cost of ownership (TCO) is explicitly considered in tenders, sustainable choices are often excluded.

Another challenge is the long payback periods for some measures, which may not align with political or managerial timelines. Without dedicated funding or external incentives, efficiency projects risk being delayed or deprioritised.

Lack of Data and Measurement Infrastructure

Closely behind cost, operators cited poor data quality and limited monitoring capabilities as a critical barrier. Without granular data, such as subsystem-level energy use or real-time consumption tracking, it becomes difficult to identify any savings potential, justify investments, or verify the results of implemented measures.

This creates a vicious cycle in that insufficient data hinders business case development, which in turn blocks funding for both monitoring and upgrades.

Additional Barriers

Other, less frequently mentioned challenges include:

- → Procurement rigidity, especially the obligation to select the lowest-cost option regardless of lifecycle efficiency.
- → Operational constraints, such as tight project timelines or a focus on uninterrupted service and safety.
- → Comfort-efficiency trade-offs, where certain measures (for example, adjusted HVAC settings) may risk passenger dissatisfaction.
- → Cultural inertia, where energy efficiency is not yet embedded in the organisational mindset.
- → Technical risk aversion, especially when adopting newer technologies without long-term field validation.

Summary of challenges

In short, improving energy efficiency is not only a technical task, it is also a financial, procedural, and cultural challenge. Tackling these barriers requires:

- → More flexible procurement rules (with TCO).
- → Investment in monitoring systems.
- → Clear internal targets and leadership commitment.
- → And where possible, policy support and external funding.

The next chapters will explore how procurement practices and better regulatory frameworks can help unlock this potential.

→ New York, USA
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MTA

Procurement Practices and Total Cost of Ownership (TCO)

Procurement decisions have a lasting impact on the energy performance of urban rail systems. Vehicles, systems and infrastructure often remain in use for decades, making it essential to consider long-term efficiency, not just upfront cost.

Figure 5: Respondents' share consideration of carbon footprint and energy efficiency for tenders and purchase purposes

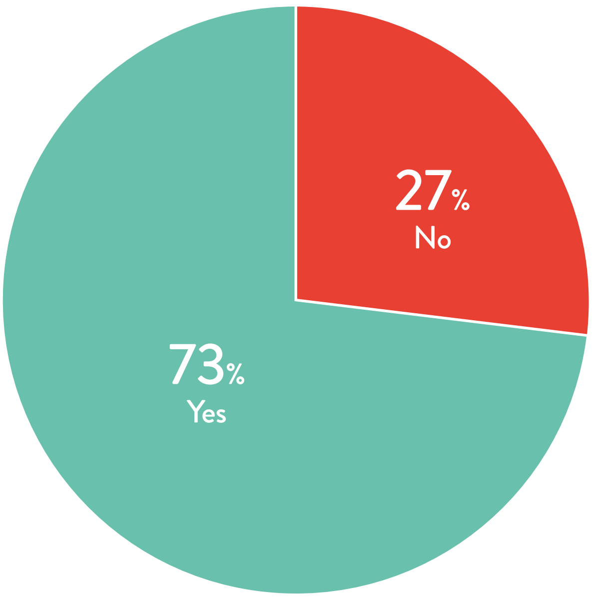
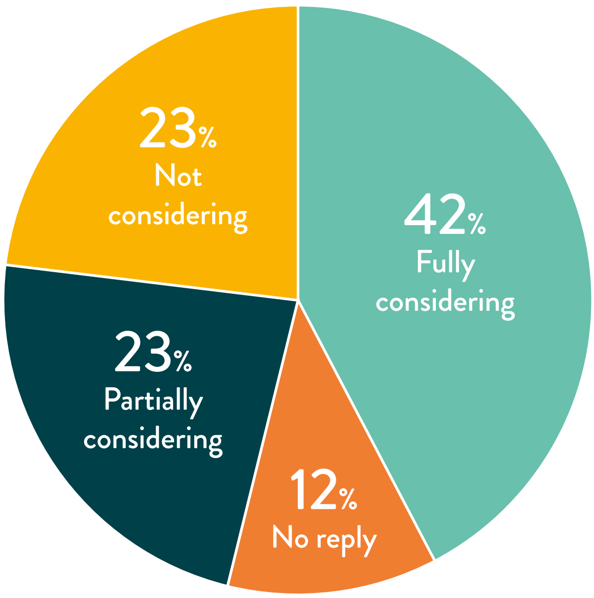


Figure 6: Consideration of TCO



Figures 5 and 6 reflect the respondents' consideration regarding the integration of energy efficiency and TCO in procurement. One-quarter do not factor energy at all, highlighting a critical opportunity to align procurement with long-term efficiency goals. The UITP VEI align procurement with long-term efficiency goals.

Roughly 75% of operators consider energy performance to some extent, yet only about half apply a robust TCO framework.

In fact, a significant share of 25% do not factor energy efficiency at all, prioritising purchase price or technical compliance instead.

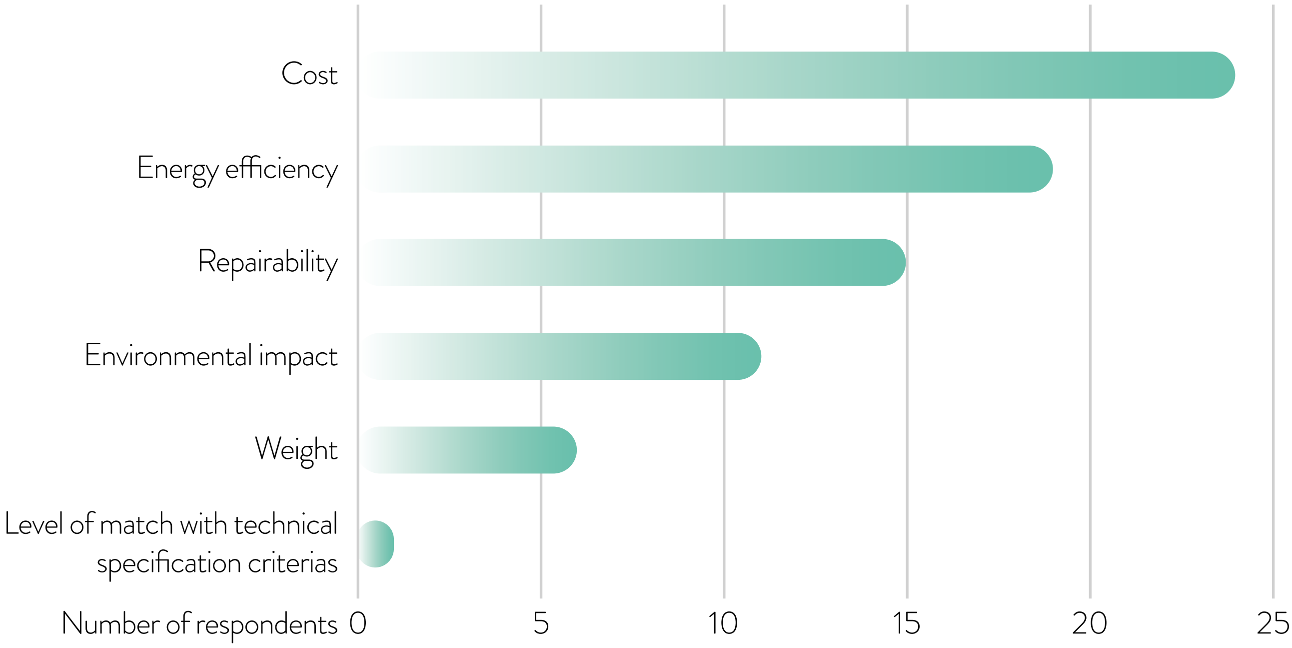
Several challenges were cited:

- → TCO modelling complexity, including reliance on vendor-provided assumptions.
- → Lack of standardised metrics to evaluate energy use.
- → Procurement rules that prioritise lowest cost, even when long-term energy savings would justify a higher initial investment.

In many cases, maintenance costs are considered, but energy consumption is only loosely addressed, or omitted altogether. Environmental impacts (for example, emissions, recyclability) are rarely weighted significantly in tender scoring.

→ Ostrava, Czechia
© DPO

Figure 7: Most important criteria when upgrading a component (respondents could choose several options)



There are encouraging developments. Some transport authorities now mandate that suppliers submit life-cycle cost calculations and energy performance guarantees (for example, kWh per car-km). In a few cases, penalties or incentives are tied to actual operational performance, shifting risk to manufacturers and promoting efficient design.

To fully unlock the potential of TCO-based procurement, agencies need:

→ Clear methodologies and tools for life-cycle costing.

→ Policy support to reform public procurement frameworks.

→ Internal training and cultural change to prioritise long-term value over short-term price.

In short, procurement is one of the most powerful levers to improve energy efficiency, but only if aligned with sustainability objectives. Agencies that embrace TCO will likely see reduced energy costs and more future-ready systems. Those that don't risk locking in inefficiencies for decades to come.

→ Manchester, UK
© Madrugada Verde

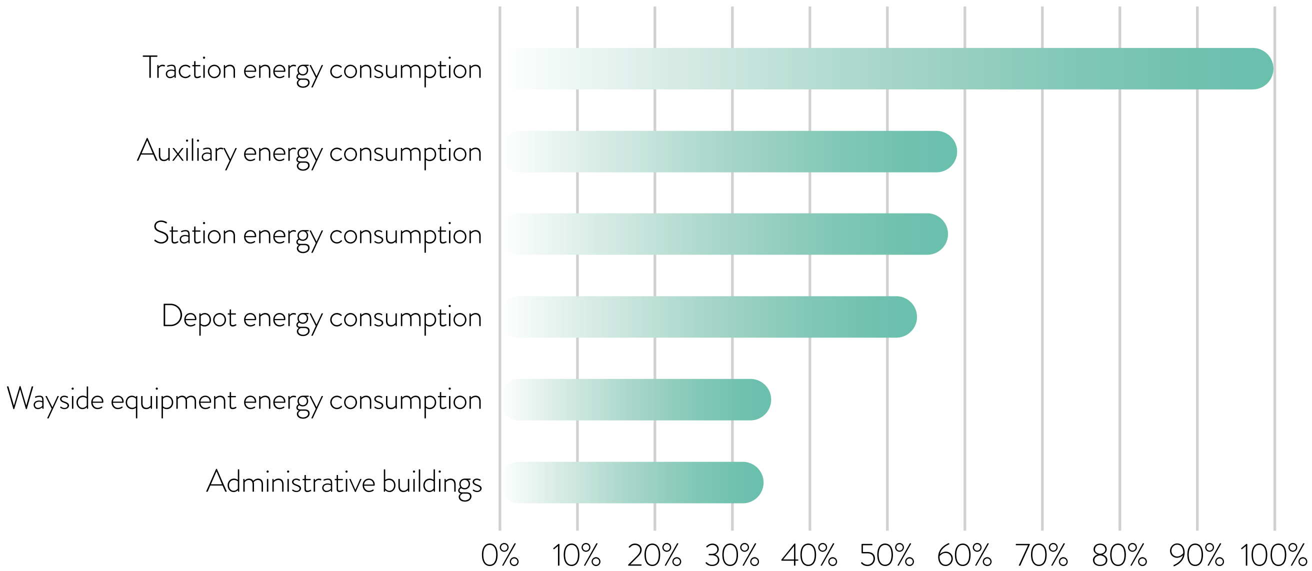
Greatest Potential for Energy Optimisation

The survey clearly identified where operators see the largest opportunities to reduce energy consumption in urban rail systems. The highest optimisation potential lies in vehicle traction, followed by auxiliary systems such as HVAC, lighting and station equipment. In contrast, wayside infrastructure (for example, signalling, cables) was consistently rated as having a relatively low effect on total energy usage.

This prioritisation reflects both the scale of energy use and the technical feasibility of making improvements. Rolling stock traction typically accounts for the majority of electricity demand, especially in metro systems. As such, any measure targeting driving behaviour, train control systems, regenerative braking or traction hardware yields significant savings.

Auxiliary systems, while smaller in consumption, offer quick wins through LED upgrades, HVAC optimisation and smarter control strategies, often at lower cost and with faster payback periods. The situation of stations and depots being similar to the latter.

Figure 8: Greatest potential for energy and cost optimisation



*The figure is based on the question: 'If you had to select a particular area to concentrate on, where the greatest potential exists to reduce or optimise energy costs in your systems, what would you choose? Kindly rank it from the most crucial (1) to the least important (6) based on your perspective.' The response matrix is then transformed to an average inverted score, where the most popular answer received 100%.

In summary, energy optimisation should focus on:

→ **Traction energy:** through efficient driving, regenerative braking, and modern traction systems.

→ **Auxiliaries:** including lighting, HVAC and station equipment upgrades.

→ **Low-priority:** wayside components, which typically offer limited savings relative to effort.

These priorities form the technical backbone of the recommendations in the following chapters and underline the need for focused investment in the most impactful areas.

Supporting Frameworks for Implementation

To translate technical potential into real-world results, urban rail operators need more than just internal measures. They require external support, strategic planning and a culture of energy management. This chapter brings together critical enabling conditions, more specifically policy frameworks, data quality, short- and long-term strategies and international case studies. These elements form the systemic foundation that underpins successful energy efficiency improvements.

Policy Support Requirements

Enabling policies are essential. Around 60% of survey respondents indicated a need for greater political support to drive efficiency initiatives. Key recommendations include:

→ **Dedicated funding and incentives**
Public programmes that offer grants, low-interest loans or tax credits specifically for energy efficiency projects in transit.

→ **Electricity tariffs and regulations**
Favourable public transport tariffs, demand-response opportunities, and enabling feed-in of regenerative energy to the grid.

→ **Procurement mandates**
Require life-cycle cost evaluations and energy criteria in public tenders.

→ **Efficiency targets and accountability**
Set measurable goals (e.g., kWh/passenger-km) and embed them into operator contracts and oversight.

→ **Capacity building and knowledge exchange**
Governments and associations should support pilot projects, publish case studies and fund industry working groups.

→ **Stimulating the supply side**
R&D funding and competitions to foster new energy-efficient technologies.

→ **Climate integration**
Include transit energy efficiency in urban climate action plans and carbon credit systems.

→ **Regulatory flexibility**
Enable innovation through modernised codes and sandbox models, investigate proper balance between requirements (for example, noise limits versus weight reduction).

→ **Public recognition**
Leadership support and recognition programmes increase momentum and institutional buy-in.

You can't manage what you can't measure.

Data and Monitoring Limitations

Despite its importance, many agencies struggle with data gaps. Common issues include:

- Incomplete metering coverage (for example, only at substations).
- Lack of real-time or granular data.
- Siloed, inaccessible or underutilised information.
- Difficulty attributing savings to specific measures.
- Inconsistent KPI definitions and lack of normalisation (for example, for weather, ridership).
- Staff and IT capacity limitations.
- Cybersecurity concerns when integrating monitoring systems.
- Missing external data (for example, weather or grid carbon intensity).

Solutions include:

- Comprehensive sub-metering (by line, subsystem, station).
- Smart meters and centralised data platforms.
- Integration of train-borne data with energy analysis.
- Predictive modelling tools for impact forecasting.
- Staff training and IT investment.
- Policy funding for monitoring infrastructure.

Vienna, Austria
© smereka

Strategic Energy Efficiency Planning

Energy efficiency must be tackled in layers, more specifically in the short-term, medium-term, and long-term:

Short-term Low-CAPEX Actions (0–2 years)

- Eco-driving, eco-parking and eco-stabling and timetable adjustments.
- Escalator, HVAC and lighting optimisation within modernisation or upgrades of existing infrastructure.
- Partial rolling stock modernisation (HVAC, lighting, new traction systems), noting that depending on the extent of the modernisation this can become a medium-term action.
- LED retrofits and motion sensors.
- Maximising regenerative braking already in use.
- Staff engagement and training.
- Utilising existing tech (for example, "eco mode" in HVAC or trains).

A tunnel under construction as part of the Bank Station Capacity Upgrade. London, UK. © TfL

→ Jakarta, Indonesia
© Ceha Rabbani

Medium- and Long-term Strategies (3–10+ years)

- New rolling stock with lightweight design, efficient motors, onboard storage and smart auxiliaries, with particular attention to rotating masses.
- Wayside energy storage and reversible substations.
- CBTC and energy-aware train control systems.
- Station retrofits: platform screen doors, solar roofs, efficient HVAC.
- Smart grid integration and demand-side management.
- System-wide energy management systems (EMS).
- Driver advisory systems with peak energy demand management based on live traffic information.
- Integration with other modes (for example, energy reuse for e-bus charging).
- Consistent efficiency-oriented renewal policies.

These strategies often coincide with capital planning and require early specification of energy goals. They also benefit from initial data and pilot gains to build internal confidence and secure external funding. Supporting frameworks, more specifically external policies, internal data intelligence, phased strategies and global collaboration, are critical to turning energy efficiency into a continuous, impactful transformation in public transport.

With the right foundation, every system can move toward a low-carbon, cost-efficient future.

10 Lessons Learnt from the Survey

The insights gathered from the UITP VEI survey and supporting analysis reveal clear patterns about the state of energy efficiency in urban rail. While many operators have begun their efficiency journeys, several structural and operational challenges remain. The following lessons synthesise the most important findings:

1. Energy efficiency is a recognised goal, but not yet a standard practice

Over 70% of surveyed operators have formal energy efficiency targets, which are often mandatory. However, the topic still competes with other priorities. In many networks, energy management is not yet institutionalised as a core strategy. Agencies that have embedded it as a top priority report greater success.

2. Data is foundational to progress

Nearly all operators measure energy use, typically at substation level, but only a few collect high-quality, granular data. Without detailed insight, it is difficult to identify savings potential, justify investment or verify results. Better data equals better decisions.

3. Operational measures offer quick wins

Simple changes such as eco-driving, smart scheduling and improved HVAC control can reduce energy use, often with minimal investment. However, only about half of the networks monitor driving behaviour systematically, leaving potential untapped.

4. Regenerative braking has huge potential, if utilised fully

More than half of the operators have implemented regenerative braking, but fewer than 20% can sell or export excess energy. Real benefits depend on having the infrastructure to capture, store or reuse regenerated energy within the network or grid.

→ Construction of the Bunhill 2 Energy Centre, which re-uses waste heat from the London Underground to heat homes © Joel Ford/TfL

5. Cost remains a major barrier, especially for CAPEX measures

Many efficiency improvements depend on long-term investment, often only feasible during rolling stock or infrastructure renewals. Procurement practices still prioritise upfront cost over life-cycle performance, which limits the adoption of efficient technologies.

6. Peak demand costs matter

For over 40% of operators, peak power significantly drives energy bills. Yet efficiency measures often focus only on reducing total kWh, not demand peaks. A holistic view is needed to realise the full financial benefits of energy savings.

7. TCO is gaining ground, but not universally applied

Just over half of the respondents reported using total cost of ownership in procurement decisions. However, 25% still ignore energy efficiency completely when selecting components. Modelling and valuing efficiency in tenders remains a weak point.

8. Cultural change and staff engagement are key enablers

Agencies that involve staff, train operators and communicate the value of energy efficiency see better outcomes. A culture that values innovation and sustainability helps to integrate energy thinking into everyday operations.

9. Efficiency and service quality can go hand in hand

Survey responses and case studies confirm that energy savings do not require any compromising on safety, comfort or performance. In fact, many efficiency upgrades (such as newer trains or optimised driving) improve service quality and reliability.

10. Collaboration and policy support are essential

Common challenges, such as costs, data and procurement, require shared solutions. Peer learning, joint procurement and supportive regulations can accelerate progress. Around 60% of respondents called for stronger political backing to advance their goals.

Energy efficiency in urban rail is a journey, not a one-time fix. The tools and strategies are available and many networks are moving in the right direction. To go further, agencies must invest in better data, think long-term, align procurement with efficiency and foster an internal culture that prioritises sustainable operations. The lessons shared through this survey serve as a compass for organisations navigating that path and as a call to action for collective progress.

The Way Forward

Urban rail systems face rising energy costs and growing sustainability expectations. This publication has shown that energy efficiency is no longer optional, it is essential for both economic resilience and environmental responsibility. Fortunately, a wide range of proven measures, from simple operational tweaks to strategic technology investments, offer public transport operators real potential for savings and performance improvement.

Key takeaways

- → **Efficiency as priority:** Over 70% of surveyed operators have energy efficiency targets. Measures such as regenerative braking, eco-driving and LED retrofits are already widespread and effective.
- → **Layered strategy:** A combination of quick wins (for example, driving behaviour), short/mid-term investments (for example , lighting upgrades, HVAC modernisation, energy storage) and long-term strategies (for example, fleet renewal, signalling upgrades) is needed.
- → **Data is key:** Effective monitoring, especially of KPIs such as kWh per car-km or regen energy use, is essential to make decisions and demonstrate success.
- → **Procurement matters:** Life-cycle cost approaches (TCO) and clear efficiency criteria in tenders can drive better investment outcomes.
- → **Policy and culture count:** Political support (for example, funding, tariff reform) and internal organisational culture (for example, staff engagement, leadership commitment) are critical to enabling progress.
- → **No trade-off with service:** Case studies confirm that efficiency can improve without compromising on reliability or comfort. Indeed, often both improve together.

Public transport authorities are encouraged to develop efficiency roadmaps, starting with low-CAPEX measures and evolving toward integrated, long-term improvements. Peer learning and benchmarking are key enablers. Policymakers, for their part, must ensure supportive frameworks, both financial and regulatory.

Improving energy efficiency is a continuous process, not a one-time initiative. But the rewards are cumulative: reduced operating costs, enhanced sustainability and better service. Urban rail can and must lead the way as the most energy-smart mode of mass mobility.

References

[1] Europe's Rail Report, 2024.

[2] VDV Position, 2022.

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Authors and contributors: Daniel Schambach and Michael Rüffer, Stadler; Nicolas Erb, Alstom; Christian Voss, Knorr-Bremse; Daria Kuzmina, UITP; Dominic Lauwers, UITP; Aida Abdulah, UITP.

Legal deposit: D/2026/0105/12 - Rue Sainte-Marie 6, B-1080 Brussels, Belgium | Tel +32 (0)2 673 61 00 | info@uitp.org | **www.uitp.org**