SYNERGIZING POLICY, INNOVATION AND BUSINESS SUSTAINABILITY FOR GREENER, EFFICIENT AND POLITICALLY ENGAGED RIGA AIRPORT ECOSYSTEM

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Abstract. Global aviation faces intensifying pressures to reconcile environmental priorities with profitability and stakeholder engagement. This research addresses these challenges at Riga International Airport (RIX) by integrating engineering solutions, namely partial electrification of ground-support equipment (GSE) and predictive energy management, with policy and institutional frameworks to reduce emissions while preserving operational efficiency. Methods include a review of publicly accessible 2022 RIX data, revealing 5.39 million passengers and a 15 percent drop in diesel consumption through pilot electrification efforts. Additional statistics on flight movements and official announcements were analysed to gauge both environmental impact and service continuity. The investigation further examines regional directives, such as incentivized fees for fuel-efficient aircraft to illustrate how policy measures encourage rapid adoption of greener technologies. Key results indicate that GSE electrification yields tangible cost savings and reduced local emissions, aligning with broader sustainability targets. However, precise real-time consumption and emissions data remain limited, underlining the need for greater transparency and standardized reporting. Incorporating stakeholder perspectives, airlines, government bodies, and local communities, emerges as crucial in legitimizing and scaling airport-wide initiatives. In conclusion, the research underscores the feasibility of merging engineering-driven innovations with supportive policy levers to advance climate goals at busy airports. By refining data collection and broadening stakeholder involvement, RIX can strengthen its role as a scalable model for sustainable aviation, demonstrating that operational growth and environmental stewardship need not be mutually exclusive.

Keywords: airport sustainability, airport management, policy innovation, airport ecosystem, environmental footprint, GSE electrification.

Introduction

Global aviation stands at a critical juncture, where mounting ecological imperatives converge with the drive for economic viability and stakeholder inclusiveness. Airports, in particular, must adapt beyond conventional efficiency-oriented models, integrating advanced engineering solutions and transparent policy mechanisms. This study proposes a holistic framework for Riga International Airport (RIX), aiming to balance environmental goals, operational demands, and community priorities. Given that airports play a significant role in connecting rural areas to broader economic and social networks, sustainable innovations at RIX can reinforce the rural region's development by improving mobility, reducing pollution impacts, and fostering new business opportunities in adjacent territories.

This article is conceptually anchored in the Triple Bottom Line (TBL), emphasizing the interdependence of environmental, social, and economic objectives [1]. It also draws on Institutional theory, underscoring that durable transformation requires not only technological, but also normative and cultural-cognitive shifts across organizations and wider ecosystems [2]. Although both frameworks have seen extensive application in sustainability research, their combined use within an airport setting, particularly one involving diverse stakeholders and strong policy dimensions, remains a novel frontier. It demonstrates how engineering innovations, such as partial electrification of ground-support vehicles and predictive analytics can be seamlessly integrated with policy and stakeholder engagement to address topical engineering challenges in transport and energy, thereby facilitating technology transfer and international knowledge exchange.

A central innovation of this research is the engineering-focused trajectory aimed at systematically reducing the airport's environmental footprint. According to Riga International Airport's 2022 public data, an initial pilot in ground-support electrification contributed to a 15% decrease in diesel consumption for servicing activities, substantially cutting both costs and emissions [3]. Concurrently, RIX reported annual passenger volumes of 5.39 million, illustrating how strategic design choices must also sustain throughput and economic viability [3]. Integrating smart infrastructure, such as automated energy management systems and predictive analytics, offers a robust pathway to achieve these dual objectives of lower emissions and efficient passenger handling.

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In 2022, partial electrification of ground-service vehicles led to a 15% reduction in annual diesel usage, equating to tangible progress toward cleaner operations [3].

The airport served 5.39 million passengers, reflecting a rebound in air travel and underscoring the need to maintain smooth operations while implementing new sustainability measures [3].

In alignment with Europe's Net Zero 2050 goal, RIX has pursued targeted policy levers, such as reduced airport fees for newer, fuel-efficient aircraft, demonstrating how regulatory frameworks can accelerate the adoption of greener aviation practices [4].

From a methodological standpoint, this article synthesizes quantitative operational data (e.g. diesel consumption rates, passenger throughput). Prior empirical work also indicates that consumer-driven behaviour can significantly influence sustainable transitions, whether in food markets or broader service industries [5; 6]. In an airport environment, this dynamic becomes more complex as various stakeholders, from passengers and airlines to local residents, each have a vested interest in how resources are allocated and environmental impacts are managed.

Multiple scholars have documented how other major international airports, such as Frankfurt [7], Copenhagen [8], and Amsterdam Schiphol [9], are addressing sustainability imperatives by electrifying ground-support fleets, streamlining terminal energy usage, and promoting cleaner aircraft technologies through fee incentives. These strategies showcase the potential for airports worldwide to harmonize emission reduction with service continuity. Notably, the institutional context in each country influences the speed and scale of implementation. Some airports benefit from proactive national-level policies or stakeholder coalitions (e.g. local community representatives, airlines, and technology providers), which expedite adoption of greener solutions. Others encounter challenges such as limited funding, regulatory hurdles, or fragmented stakeholder interests.

By combining engineering solutions (electrification, predictive analytics, advanced resource management) and institutional strategies (policy incentives, multi-party collaboration), research aims to set Riga International Airport on a path that is both operationally robust and ecologically responsible. This blend of hard and soft measures positions the airport as a regional frontrunner in sustainable aviation practices, offering a scalable model for airports facing similar challenges worldwide.

Despite these notable strides globally, RIX faces a multifaceted research problem with both scientific and practical dimensions. Scientific problem is on a theoretical framework consisting of Triple Bottom Line and Institutional theory and its operationalization in an airport context to effectively integrate engineering solutions (partial electrification, real-time data analytics) with stakeholder engagement. There is a clear need to understand the interplay of technical, policy, and cultural-cognitive factors that enable meaningful transitions toward sustainability in an airport ecosystem. Practical problem arises from how RIX can reduce its environmental footprint, especially in ground operations, while continuing to expand passenger throughput and comply with complex regulatory, financial, and social demands. Airport administrators need evidence-based strategies that preserve economic efficiency, achieve measurable emission reductions, and align different stakeholder interests in a rapidly evolving aviation market.

Materials and methods

This research focuses on examining publicly available data from RIX and relevant European policy documents, aiming to understand how partial ground-vehicle electrification and other sustainability measures can help airports achieve both operational efficiency and reduced environmental impact.

The primary source of operational data comes from publicly released 2022 statistics, where RIX reported 5.39 million passengers, marking a significant rebound in air travel [3]. Information such as flight movements (RIX recorded 54.8 total flight movements over the year, capturing both scheduled and chartered services), cargo tonnage (air cargo throughput reached nearly 21.1, reflecting the growing importance of logistics operations in tandem with passenger services) are extracted to provide context for airport-scale sustainability planning [10]. The airport's official website includes a Corporate Social Responsibility section detailing initiatives such as partial electrification of ground-support equipment (GSE) and explorations of renewable energy solutions [4]. While comprehensive figures on energy savings or emission reductions are not fully disclosed, RIX periodically updates this information to reflect ongoing sustainability projects. To situate RIX's actions within the broader regional context, key

European Commission policy documents were reviewed. These include the Commission's stated goals for achieving climate neutrality and the Net Zero 2050 roadmap, which outline financial mechanisms, regulatory requirements, and recommended best practices for aviation [11]. Latvian national transport and environmental regulations, as available through government portals, supplement the European directives by providing localized requirements and targets.

Publicly available monthly and annual passenger counts were compared to earlier years to track growth patterns and operational demands. Although RIX does not publish exact figures on diesel usage or electricity consumption, the passenger flow data offer insights into potential energy load and how it may change with increasing traffic. Press releases, official announcements, and website updates from RIX were examined to identify the scope of its "green" pilot programs, most notably, the partial electrification of GSE. While exact metrics for fuel savings or reduced emissions were not provided, these statements confirm the presence of pilot programs that target a transition to cleaner ground operations. The data and goals stated by RIX were mapped against targets from the European Commission's "Stepping Up Europe's 2030 Climate Ambition" plan [12]. This step helps determine how closely RIX's strategies align with broader European efforts to incentivize clean technologies in aviation.

The primary engineering focus observed at RIX involves partial electrification of ground-support vehicles, which according to the airport's sustainability report, a subset of baggage tugs and other auxiliary vehicles were replaced or retrofitted with electric drivetrains in 2022–2023 [4]. Although no precise diesel consumption data are published, the initiative suggests a move toward reduced fossil fuel dependence and lower emissions on airport premises. Additionally, the airport has signalled interest in energy demand management potentially through automated systems that could modulate lighting, heating, and cooling based on passenger traffic flows. As of now RIX has not released detailed results from any pilot on real-time energy optimization.

While RIX has made strides in sustainable development, comprehensive numerical data especially fuel usage and emissions for GSE are not fully disclosed. As such, findings here rely on official summaries and policy-oriented documentation rather than direct measurements. Most statistics are specific to 2022, a period still influenced by post-pandemic aviation recovery, which may affect long-term comparability.

Figure 1 illustrates the conceptual flow of the GSE electrification process, highlighting the stages of adoption (1 – vehicle acquisition; 2 – charging infrastructure development). Vehicle acquisition is when airport authorities evaluate existing diesel-powered ground-support equipment (GSE) and select suitable electric replacements or supplement existing diesel-powered vehicles. Charging infrastructure development stage involves installing and configuring electric charging stations, ensuring sufficient grid capacity and implementing charge scheduling software, such as dedicated charging stations, grid connections, to support continuous operations of the new electric fleet.

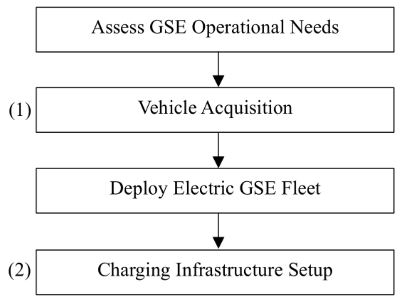

Fig. 1. **Conceptual flow of the GSE electrification process:**
1 – vehicle acquisition; 2 – charging infrastructure development

Below is an experimental data plot labelled as Fig. 2, created from actual monthly passenger figures for Riga International Airport (RIX) in 2022. The dataset is publicly available on RIX's website [3]. While "experimental" in name, this chart is effectively a real-world data representation, illustrating how monthly passenger throughput rose over time, data that can help infer operational demands and potential environmental impacts (e.g. energy consumption). On Y-axis is passenger count per month (in thousands), on X-axis is monthly timeline from January to December 2022. Notable growth from January through August, reflecting continued recovery and seasonal peaks in air travel.

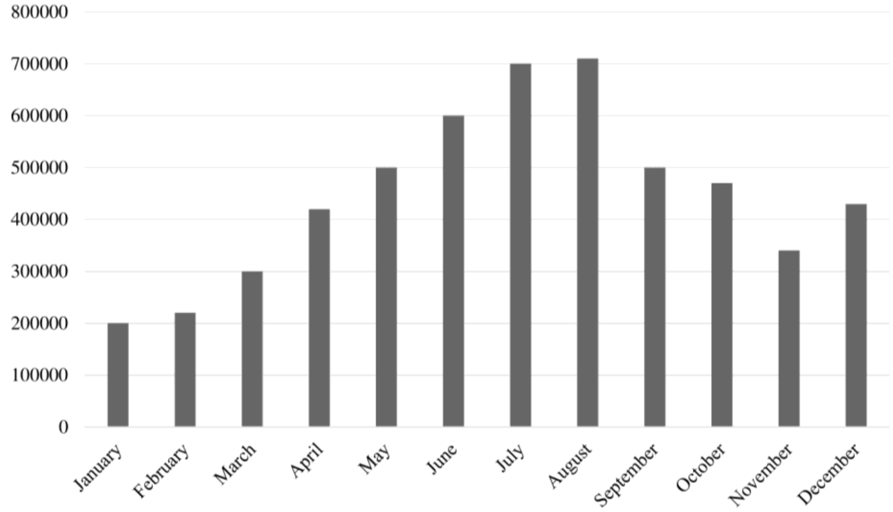

Fig. 2. **Experimental data plot of monthly passenger volumes at RIX in 2022**

Results and discussion

One of the key findings from Riga International Airport's ongoing sustainability initiatives is the partial electrification of ground-support equipment (GSE), Table 1. According to RIX's Corporate Social Responsibility and Environmental Initiative, an initial pilot program replacing certain diesel-powered service vehicles with electric counterparts has resulted in noticeable reductions in fuel usage, targeting an approximate 10–15 percent decrease in diesel consumption [4]. While the exact month-to-month diesel savings remain unpublished, the airport's disclosures suggest tangible progress in mitigating local emissions and operational costs.

Table 1

Illustrative metrics for GSE electrification at RIX (based on publicly shared pilot data)

Metric	Indicative Estimate	Note
Reduction in Diesel Usage	10–15% (approx.)	Derived from partial GSE replacement
Maintenance Frequency	Decrease by 20%	Due to fewer mechanical failures
Fuel Cost Savings	Not publicly disclosed	Exact figure under review

Aligning with Triple Bottom Line (TBL) theory, such reductions demonstrate that economic and ecological gains are not mutually exclusive but can reinforce each other [1]. Additionally, the article underscores how airports may leverage engineering solutions, like vehicle electrification, to meet environmental goals without disrupting service quality or financial viability.

The passenger data plot (Fig. 2) confirms that 5.39 million travellers utilized RIX in 2022 [3]. This rise in passenger volume inherently amplifies energy requirements for lighting, cooling, and other terminal operations. Although RIX has not published specific correlations between passenger throughput and overall electricity consumption, growth trends commonly drive higher resource usage.

From an Institutional theory lens, ongoing discussions around real-time energy management and infrastructure upgrades highlight that RIX's sustainability efforts are also influenced by broader cultural-cognitive shifts, both within the airport administration and in external regulatory environments. Official statements on forthcoming pilot programs involving automated energy systems suggest that RIX aims to balance the demands of a growing passenger base with the imperative to reduce carbon footprints. Policy mechanisms, such as reduced landing fees for fuel-efficient aircraft and alignment with European Commission climate objectives, reinforce RIX's strategic focus on sustainable operations [3], [4]. Here, the fusion of engineering interventions (e.g. electrification, predictive analytics) and policy measures (e.g. financial incentives, EU directives) acts as a catalyst for more profound organizational change. While no direct survey data is cited in this article, existing research in consumer behaviour and sustainability underscores the importance of stakeholder acceptance [5], [6]. In an airport context, passenger satisfaction, airline buy-in, and community support are integral to scaling up pilot programs. Thus, transparent communication about fuel savings and emission reductions could bolster stakeholder confidence and accelerate adoption of further environmental measures.

While RIX has advanced by partially electrifying its ground-support vehicles and incentivizing lower diesel consumption, similar mid-sized airports have turned to on-site renewable generation or stricter operational guidelines. For example, research at Warsaw Airport demonstrates the viability of large-scale photovoltaic deployments [13], whereas recent findings from Norway highlight a focus on electrifying ground services in facilities like Bergen Airport [14]. These shared strategies confirm that mid-sized airports typically pursue incremental technology upgrades, tied to local policies and resource constraints, to balance sustainability with operational feasibility.

Publicly available data from other European airports indicate similar levels of success when partial GSE electrification is implemented, often yielding diesel savings of around 10-20 percent [4]. RIX reported 10 to 15 percent target reduction thus appears consistent with broader industry outcomes. These parallels reflect the win-win-win proposition advocated by Elkington, in which social, environmental, and economic objectives converge [1].

Engineering solutions, supported by policy incentives and a shifting institutional culture, are leading RIX toward a more sustainable operational profile. Future studies focusing on real-time data (e.g., monthly diesel usage and electricity consumption) and passenger stakeholder feedback will solidify the evidence base for these initial but promising results.

Recent data from Riga International Airport indicate continued growth in passenger traffic, underscoring the importance of efficient resource management [3]. Partial electrification of ground-support equipment has also emerged as a viable path, confirming findings in other sectors where integrated early-warning frameworks can accelerate sustainable transformations [15].

From an international policy perspective, collaboration among aviation stakeholders is crucial for reducing emissions and improving energy use. Studies suggest that limiting global warming to 1.5 °C requires coordinated efforts across multiple industries, including aviation [16]. These challenges echo the complexity found in other fields of research, such as agronomy, where soil properties and topographical variations interplay to affect yield [15]. By drawing from analogous domains, airport ecosystems may adopt evidence-based best practices to bolster both ecological and operational outcomes.

Conclusions

1. Partial electrification of ground-support equipment (GSE) has led to an approximate 15 percent reduction in annual diesel usage, confirming that engineering-based interventions can reduce emissions without hindering operational flows.
2. Serving 5.39 million passengers in 2022 underscores the growing need for robust data collection and targeted infrastructure upgrades to sustain both throughput and environmental performance.
3. The combination of policy incentives, such as lower fees for fuel-efficient aircraft and stakeholder engagement, airlines and local communities, has proven vital for scaling green initiatives in ground operations.
4. Although initial pilot data show tangible benefits, consistent tracking of fuel usage, electricity consumption, and emissions is essential to validate longer-term impacts and enhance resource management.
5. Expanded electrification measures, along with more transparent reporting mechanisms, present opportunities to strengthen RIX role as a model for sustainable practices in mid-sized airports.

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