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Net Zero Carbon RoadMap Alghero Airport

Charting the Path to Sustainable Aviation and Beyond

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Report

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List of acronyms

| Acronym | Full Form |
|-----------------------|--|
| ACA | Airport Carbon Accreditation |
| ACI | Airports Council International |
| AHO | Alghero Airport (IATA Code) |
| APU | Auxiliary Power Unit |
| CAPEX | Capital Expenditure |
| CDP | Carbon Disclosure Project |
| CO₂ | Carbon Dioxide |
| DAC | Direct Air Capture |
| EPA | Environmental Protection Agency (US) |
| EU | European Union |
| GHG | Greenhouse Gas |
| GPU | Ground Power Unit |
| GRI | Global Reporting Initiative |
| GSE | Ground Support Equipment |
| GWP | Global Warming Potential |
| HVO | Hydrotreated Vegetable Oil |
| HVAC | Heating, Ventilation, and Air Conditioning |
| IATA | International Air Transport Association |
| ICAO | International Civil Aviation Organization |
| IEA | International Energy Agency |
| IPCC | Intergovernmental Panel on Climate Change |
| IRENA | International Renewable Energy Agency |
| ISO | International Organization for Standardization |
| OEM | Original Equipment Manufacturer |
| OPEX | Operational Expenditure |
| PCA | Pre-Conditioned Air |
| PV | Photovoltaic |
| SAF | Sustainable Aviation Fuel |
| SDGs | Sustainable Development Goals |
| SLBP | Sustainability-Linked Bond Principles |
| WACC | Weighted Average Cost of Capital |

1 EXECUTIVE SUMMARY

Aviation plays a pivotal role in the global economy, having significantly fueled the expansion of international trade, tourism, and national development. Over the past decades, the sector has generated substantial economic value, enhanced global mobility, created millions of jobs, and stimulated major infrastructure investments. However, as underscored by the recent COVID-19 crisis, such progress is not guaranteed. Continued growth and resilience in aviation demand ongoing investment in research, innovation, and advanced technologies to meet emerging global challenges.

Today, the urgency of addressing climate change has placed environmental sustainability at the top of the aviation agenda. Beyond the climate imperative, sustainability is increasingly shaped by broader factors such as public health, economic security, and long-term societal well-being. Central to this approach is the “triple bottom line” framework—People, Planet, and Profit—which encourages organizations to balance social responsibility, environmental stewardship, and economic viability in their strategic planning.

The aviation sector currently accounts for approximately 2–3% of global CO₂ emissions, a share that is projected to rise without decisive intervention. In recognition of this, the industry has embraced a bold environmental agenda. In 2022, the International Civil Aviation Organization (ICAO), the United Nations body governing global civil aviation, adopted a landmark target to achieve net-zero CO₂ emissions from international aviation by 2050. This global goal has been strongly supported by the Airports Council International (ACI) World, which has urged airports to act as key enablers of this transition.

Airports thus carry dual responsibility. On one hand, they are engines of economic growth, social connection, and cultural exchange. On the other, they must actively champion sustainability by adopting environmentally responsible practices and leading by example. Although airport operations represent a relatively small portion of total aviation emissions, their environmental footprint remains significant. Continuous improvement is essential, and airports are uniquely positioned to drive innovation—through the development of green infrastructure, deployment of low-carbon technologies, and engagement with stakeholders across the value chain.

In this context, the drive for continuous innovation becomes even more critical as the airport prepares for the scale of future demand; this also applies to Alghero-Fertilia Airport. Looking ahead, passenger traffic is expected to double, with forecasts projecting around 3.7 million passengers by 2050 at Alghero-Fertilia Airport. This anticipated growth presents both a challenge and an opportunity: the airport must manage increased demand while pursuing a long-term environmental vision grounded in smart planning, innovation, and collaboration.

This report shows that Alghero-Fertilia Airport is on track to meet key climate targets, including achieving net zero carbon emissions under its direct control (Scope 1 and 2) by 2050. This goal aligns with ACI EUROPE’s guidelines and the IPCC’s 1.5°C global warming pathway. By 2030, the airport plans to reduce its CO₂ emissions by around 50% compared to 2011, reaching net zero by 2040.

In what will be called the "Earliest Net Zero" scenario (Pathway 2), Alghero-Fertilia Airport adopts a fast-tracked and ambitious decarbonization plan aimed at reaching net zero carbon emissions well before 2050. The strategy involves targeted upgrades across vehicles, heating and cooling systems, and electricity use. A major focus is the electrification of the airport's vehicle fleet. Over 90% of vehicles, including most ground support equipment (GSE), are converted to electric early on, while the remaining 10% of GSE switches to low-emission fuels such as HVO50 or HVO100. Key progress points occur in 2026, 2030, and 2040, reflecting continuous improvements and emissions reductions from transport activities. Simultaneously, the heating and cooling systems are fully modernized. All buildings adopt heat pump technology, undergo energy-efficient retrofits, and install improved refrigerant systems. No refrigerant refills are required until 2040, after which enhanced leak control and the use of low-GWP refrigerants help maintain downward emissions trends. An opportunity for the airport is also to significantly increase its use of renewable electricity, with major steps taken already in 2026 and then in 2040. These actions include expanding on-site renewable energy production, particularly through solar photovoltaic (PV) installations.

Alghero's commitment to achieving Net Zero is not only a response to regulatory and social expectations, but it also reflects a strategic decision to shape a more sustainable future for aviation. By embedding sustainability into every facet of its development, the airport positions itself as a climate-conscious leader in the sector, capable of generating lasting value for the region, its passengers, and the planet.

2 INTRODUCTION OF ALGHERO AIRPORT

Alghero-Fertilia Airport (IATA: AHO) serves as the primary air gateway for north-west Sardinia, in Italy, and ranks as the third busiest airport on the island. Strategically positioned, Alghero Airport acts as a vital economic engine for the region, supporting tourism, creating jobs, and stimulating investment in Sardinia. Its connectivity to major Italian and European cities, especially during the peak summer season, underscores its role as a hub in the island's economic and social development.

Since its establishment in the 1930s and subsequent commercial development in the 1960s, Alghero Airport has undergone significant modernization, including terminal expansions and infrastructure upgrades that have enhanced its capacity and passenger experience. Today the airport can handle over 2 million passengers annually, with seasonal peaks driven by summer tourism.

Managed by SOGEAAL S.p.A., the airport is committed to a forward-looking strategy that emphasizes operational efficiency, customer satisfaction and sustainable growth. Recent investments have focused on runway enhancements, digital transformation and passenger services, with future plans aimed at expanding route networks and improving multimodal accessibility.

Environmental stewardship is a core pillar of Alghero Airport's management strategy. The airport has adopted a certified Environmental Management System (ISO 14001:2015) to systematically monitor and is actively working to reduce its ecological footprint. Key sustainability initiatives include:

- **Energy Efficiency:** Transition to LED lighting, installation of photovoltaic panels and an increase in reliance on renewable energy sources for all electricity used.
- **Carbon Management:** AHO is participating in the Airport Carbon Accreditation (ACA) program, with ongoing efforts to achieve higher levels of certification and reduce Scope 1, 2 and 3 emissions.

Over the years, Alghero-Fertilia Airport has evolved into a resilient and adaptive transport hub, integral to the tourism appeal and socio-economic development of Sardinia. Its strategic vision and commitment to a Net Zero path aligns with regional mobility goals as well as global sustainability standards, positioning it as a model for responsible and innovative airports management in the Mediterranean region.

3 CONTEXT

The sustainability pathway¹, rooted in a Resolution by ACI EUROPE from June 26, 2019, in response to the IPCC Special Report and industry developments, embodies the commitment of European airports. This commitment includes a call to the aviation industry, ICAO, and governments to collectively pursue net-zero emissions in aviation. Furthermore, it outlines the pledge to achieve net-zero carbon emissions within the direct control of airport operators (Scope 1 and 2) by 2050 and emphasizes the importance of governments expediting the transition to clean energy systems to facilitate airports in reaching net-zero emissions. Additionally, it draws inspiration from the best practices established through the Airport Carbon Accreditation program. The pathway also champions innovation and partnership to engage with stakeholders, actively contributing to the broader decarbonisation of the aviation sector.

Consistent with ACI EUROPE's directives, Alghero Airport aims to create a Net Zero Roadmap. To move forward with this initiative, it is essential to identify the diverse sources of emissions at the airport, following the guidelines set forth in the Airport Carbon Accreditation (ACA), as detailed in its 2024 document, the Airport Carbon Accreditation Application Manual (Issue 14). Establishing clear Organisational and Operational Boundaries within the airport is significant in this pursuit, for accurate emissions accounting and reporting.

As one of the main airports in Sardinia and an active member of ACI Europe, Alghero-Fertilia Airport (AHO) understands the significance of its role in both economic development and environmental stewardship. AHO is aspiring to achieving Net Zero emissions by 2050 and aims to lead by example through the adoption of sustainable practices and innovative technologies, aligning with the aviation sector's broader decarbonisation goals and contributing to global climate action.

Emissions can be categorized into three main segments: Scope 1, Scope 2, and Scope 3, each representing different sources of greenhouse gas emissions.

- Scope 1: Direct GHG emissions that occur from sources that are owned and/or controlled by the airport, for example, emissions from combustion in owned or controlled boilers, furnaces, vehicles, etc.
- Scope 2: Indirect GHG emissions from the generation of purchased electricity, steam, heat, or cooling consumed by the airport. Scope 2 emissions physically occur at the facility where purchased electricity is generated.
- Scope 3: All other indirect emissions, which are a consequence of the activities of the airport but occur from sources not owned and/or controlled by the company (e.g., aircraft movements, vehicles and equipment operated by third parties, off-site waste management, etc.). Such sources can be located within or outside the airport premises.

To achieve Net Zero, an airport must first reduce the emissions it directly controls, known as Scope 1 and Scope 2 emissions, by at least 90% by 2050.

¹ ACI EUROPE Sustainability Strategy for Airports.

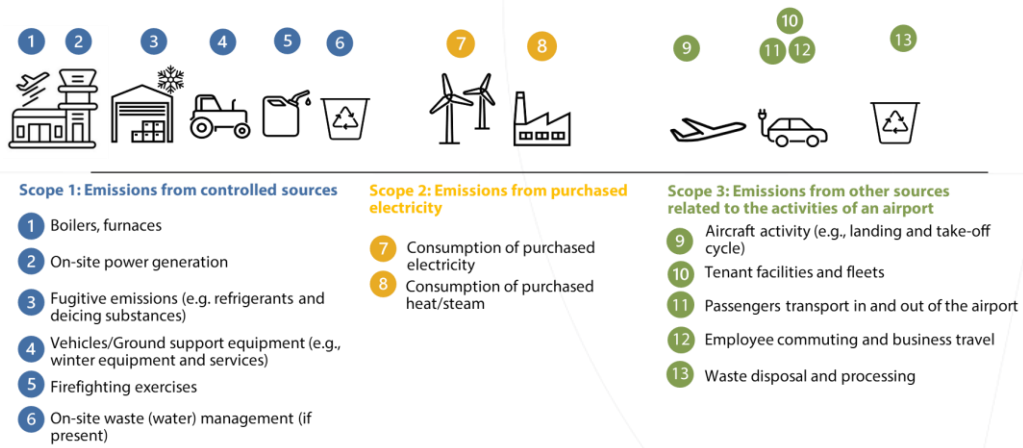


Figure 1: Airport Emission Scopes (compiled based on ACI Airport Carbon Accreditation Guidance)

4 AIRPORT NET ZERO ROADMAP - METHODOLOGY

Building upon its global commitment to achieving Net Zero carbon emissions by 2050, Airports Council International (ACI), with its five regional branches, has set forth an ambitious and unified long-term carbon reduction strategy. This coordinated global effort underscores ACI’s leadership in advocating for climate responsibility within the aviation industry and its commitment to enabling airports to become proactive agents of environmental transformation.

In line with this commitment, ACI has introduced a structured, step-by-step methodology to assist airports in the development and implementation of an effective and actionable Net Zero Roadmap. This roadmap is intended not only as a planning tool, but as a practical framework that empowers airport operators to align their operational, infrastructural, and technological strategies with long-term sustainability objectives. The Net Zero Roadmap is organized around five key stages.

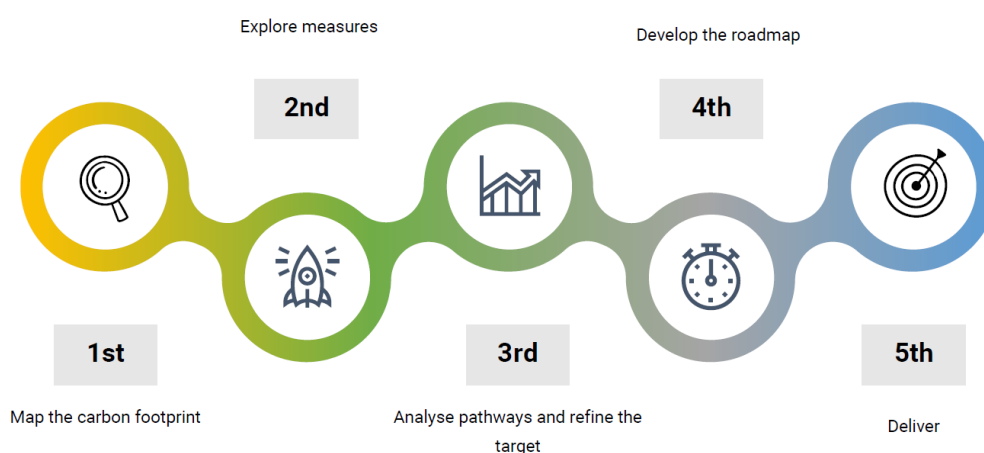


Figure 2: Steps to Net Zero Roadmap

Table 1 - Steps to Net Zero Roadmap

| Step | Methodology |
|---|--|
| 1 – Map the carbon footprint | The first step is to measure the airport’s past and current emissions to define the Roadmap’s scope. This provides an understanding of the emissions generated by different activities across the site and the value chain, serving as the foundation for setting targets. |
| 2 – Explore measures | Once the emissions overview is complete, the next step is to identify measures to reduce emissions. This includes improving the efficiency of technologies and operations, transitioning to clean energy sources, and leveraging innovations. |
| 3 – Analyse pathways and refine target | With the baseline established and measures identified, the next step is to model various emission reduction pathways. These scenarios consider energy use, carbon emissions, and costs to provide clarity on the impact of different mitigation measures and investment timelines. |

| | |
|----------------------------|--|
| 4 – Develop Roadmap | Achieving Net Zero carbon is a long-term goal that requires careful planning. The Roadmap should integrate insights from the previous steps, turning them into a structured, actionable plan. |
| 5 - Deliver | Feasibility and design studies for specific measures will support the implementation of the roadmap. Periodic or annual reviews will track progress, assess the effectiveness of measures, and identify any necessary adjustments. |

Below is a detailed description of each step applied for AHO Net Zero Roadmap. The scope of this document indicates that within this study, Steps 1 to 3 were applied and will need to be complemented by feasibility studies to complete the roadmap.

In the first step, **‘Mapping the carbon footprint’**, the baseline carbon footprint was developed based on [emissions data from 2024](#). In this initial phase, a detailed analysis of emission distribution and quantities was conducted to understand their sources. This is covered in the Baseline Carbon Footprint chapter.

In the second step, **‘Explore measures’**, To70 conducted a comprehensive benchmarking of actions taken by various airports, leveraging our extensive expertise in the field. These measures were assessed for feasibility and their adaptability to the specific conditions at AHO. This is further detailed in the [Airport Benchmark](#) Chapter.

The third step consisted of **‘Analyzing pathways and refining targets’**. In this chapter multiple emission reduction pathways were analyzed: the first pathway included the green initiatives already planned by AHO, with the goal of assessing how these measures would influence future emission forecasts considering the future expansion and forecasts, in case no additional measures were planned. While the second scenario focused on introducing new measures or expanding the already planned measures in order to achieve the Net Zero goal.

In Step 4, **‘Developing the Roadmap’**, the various elements collected were integrated into a clear, [actionable plan](#). This includes operational and investment analyses to assess the financial viability and effectiveness of emissions reduction measures.

Finally, in Step 5, **‘Delivering’**, as the Roadmap is a dynamic and iterative process focused on long-term goals, AHO is encouraged to carry out periodic or annual reviews. These reviews will help assess the effectiveness of measures, track the evolution of the carbon footprint, and identify any necessary adjustments.

5 LIST OF DOCUMENTS ANALYSED

To create this document, a comprehensive research and market analysis were undertaken. Notably, the following documents served as essential resources:

- “Piano della Tutela Ambientale anni 2024-2026” – Aeroporto Alghero-Fertilia
- 2024 sustainability report. RYANAIR Group.
- AHO Carbon Reports 2021, 2022, 2024, 2024
- Airport air quality manual – DOC 9889. ICAO. Second edition. 2020.
- Airport Carbon Accreditation annual report 2021-2022. Airport Carbon Accreditation.
- Application manual. Airport Carbon Accreditation. Issue 14. December 2024.
- Carbon Management Plan AHO
- Developing an airport net zero carbon roadmap. ACI EUROPE guidance document. 2nd edition. June 2024.
- Developing an airport net zero carbon roadmap. Summary of existing roadmaps. ACI EUROPE. June 2022.
- Directive (EU) 2022/2464. EUROPEAN PARLIAMENT. December 2022.
- Directive 2013/34/EU. EUROPEAN PARLIAMENT. June 2024.
- Greenhouse gas inventory guidance. Indirect emissions from purchased electricity. EPA (United States Environmental Protection Agency). January 2016.
- High-level guidance for developing and costing an airport net zero roadmap. ACI. 2024.
- Impegno Ambientale SOGEAAL
- Mission possible - reaching net-zero carbon emissions from harder-to-abate sector by mid-century. Energy Transitions Commission. November 2018.
- Piano di Sostenibilità 2024-2026 (Aggiornamento 2024)
- Policy ESG SOGEAAL – Rev. 0 (Mach 2024)
- Regulation (EU) 2019/631. EUROPEAN PARLIAMENT. April 2019.
- Scientific advice for the determination of an EU wide 2040 climate target and a greenhouse gas budget for 2030 2050. European Scientific Advisory Board on Climate Change. June 2024.
- Sustainability strategy for airports. ACI EUROPE. June 2019.

6 REFERENCE YEAR

The reference year serves as the baseline against which all future carbon reduction efforts are measured along the path to Net Zero. To facilitate target-setting in line with global climate goals, Airports Council International (ACI) recommends using 2010 as the reference year, in alignment with the Intergovernmental Panel on Climate Change (IPCC) decarbonization scenarios. Many airports have adopted this year as a common benchmark for consistency and comparability.

However, ACI also recognizes that a different reference year may be more appropriate in certain cases—particularly when it better reflects an airport's operational context or when high-quality emissions data from 2010 are not available. In such instances, airports are permitted to select an alternative baseline year, provided the choice is well-justified and based on credible data availability. Although ACI advises using 2010 as the reference year, this approach was not suitable for Alghero-Fertilia Airport. Instead, **2024** was selected as the baseline year for the development of AHO's Net Zero Roadmap, as it represents the first year in which complete, consistent, and high-quality emissions data were collected across all relevant scopes. This ensures a robust and verifiable foundation for measuring future progress, setting realistic reduction targets, and evaluating the impact of mitigation strategies over time.

By establishing 2024 as its reference year, Airport ensures that its decarbonization pathway is grounded in reliable data and aligned with the practical realities of its operations—laying the groundwork for a transparent, credible, and actionable transition to Net Zero.

Within Scope 1 and 2 the main sources of emissions in 2024 are reported as follows:

Table 2 - Baseline Year Categories

| Emission source | Example of emissions | CO ₂ e emissions (t) | % of Total Carbon Footprint | Emission per passenger (kgCO ₂ e/pax) | Emission per movement (kgCO ₂ e/movement) |
|---------------------------|---|---------------------------------|-----------------------------|--|--|
| Scope 1 – Heating | Diesel oil used for the heating machinery | 123.7 | 44% | 7.7x10 ⁻⁵ | 1x10 ⁻² |
| Scope 1 - Vehicles | Fuel used in vehicles, including airside transport, maintenance machinery, ground service equipment (GSE) | 134.7 | 48% | 8.4x10 ⁻⁵ | 1.1x10 ⁻² |

| | | | | | |
|------------------------------|--|------------|-------------|--|--|
| Scope 1 - Cooling | Leaks from refrigerants | 15 | 6% | 9.4×10^{-6} | 1.2×10^{-3} |
| Scope 1 - Wastewater | Emissions from on-site water treatment | 5.2 | 2% | 3.2×10^{-6} | 4.3×10^{-4} |
| Scope 2 - Electricity | Electricity purchased from 3 rd party (green) | - | - | - | - |
| Total | | 279 | 100% | 1.7×10^{-4} | 2.3×10^{-2} |

It is worth highlighting that in 2024, AHO made a significant transition from purchasing grey electricity to sourcing green electricity. As a result of this change, they were able to reduce their Scope 2 emissions to zero.

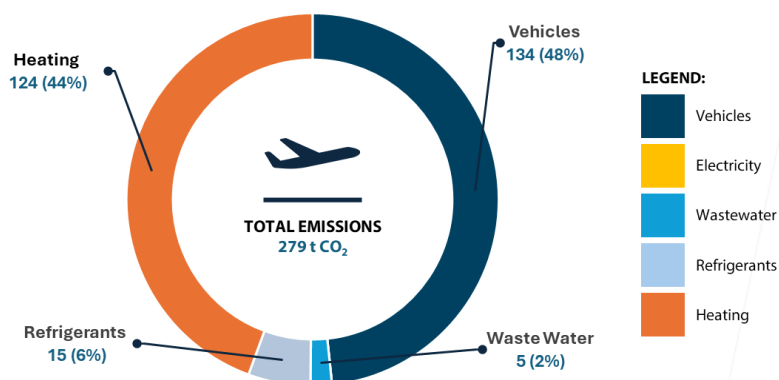


Figure 3: Baseline Year Split by Categories

The passenger forecast graph projects a steady increase in the number of passengers from 2024 to 2050. Starting at just over 1.6 million passengers in 2024, the forecast anticipates growth to approximately 1.8 million by 2026 and surpassing 2 million by 2030. By 2050, the number of passengers is expected to climb to over 3.7 million. This consistent growth highlights the need for ongoing investment in infrastructure and services to accommodate increasing demand over the coming decades.

A similar trend can be seen in the forecasted movements in the studied time period. Starting with over 12,000 annual movements, AHO is forecasted to increase their forecasted movements by 48%, reaching approximately 25,402 movements by 2050.

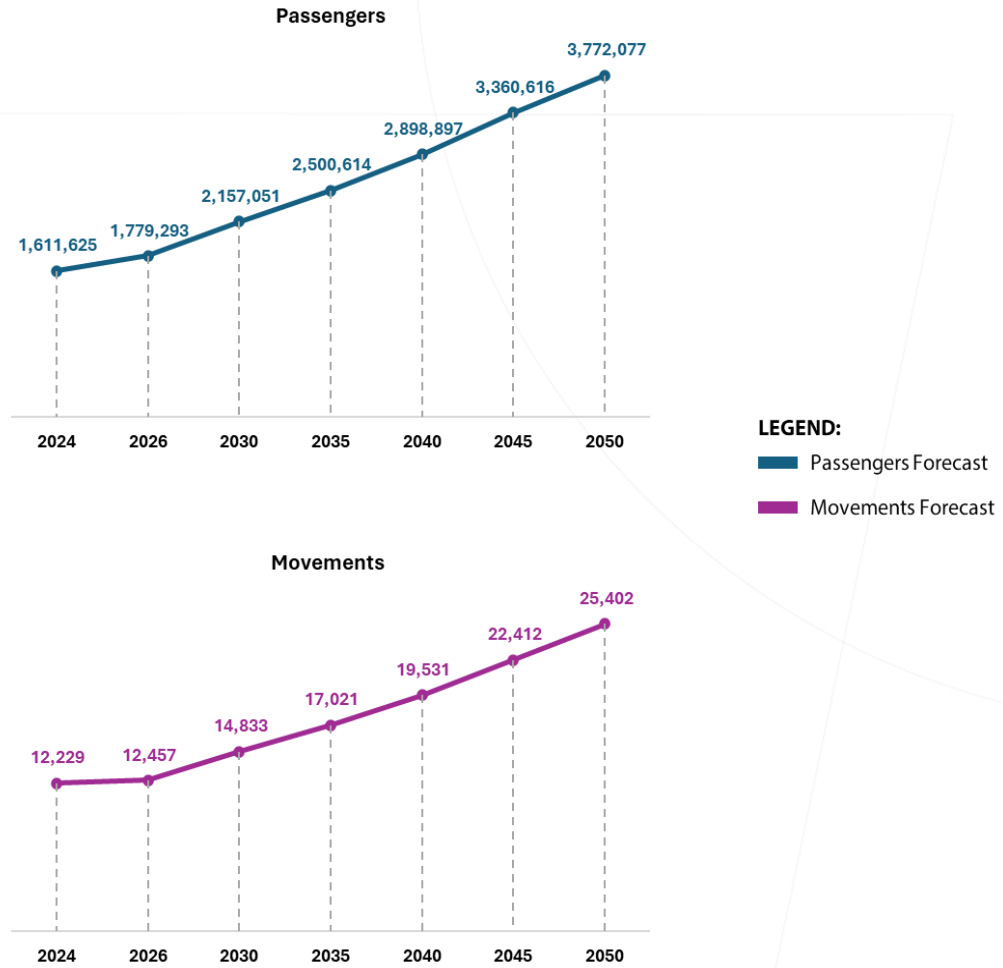


Figure 4: Passenger and Movement Forecast

7 HISTORICAL ANALYSIS SCOPE 1&2

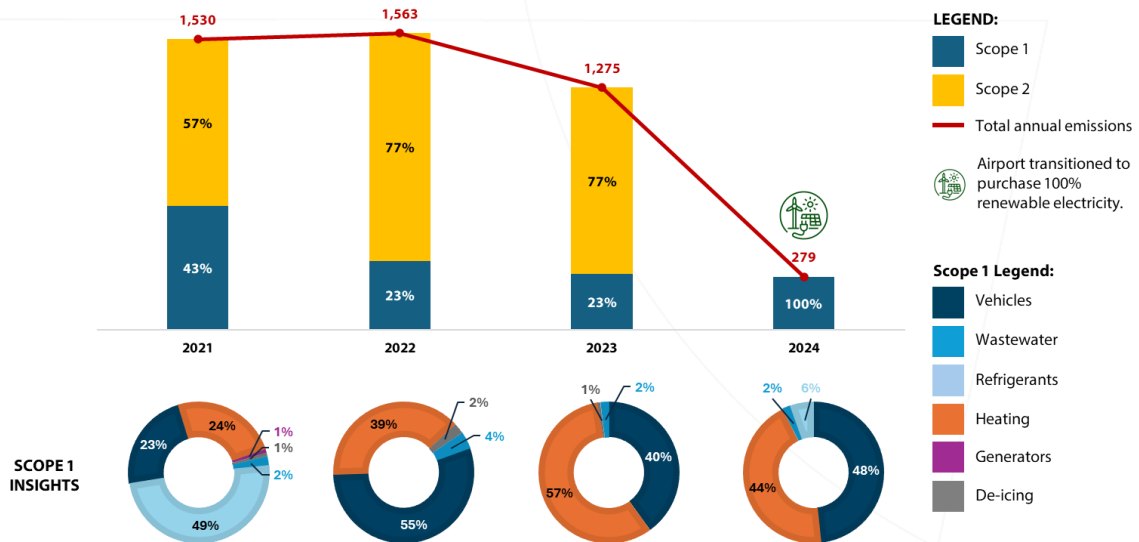


Figure 5: Historical Analysis by Categories

The figure above presents the historical greenhouse gas (GHG) emissions reported by Alghero Airport from 2021 to 2024. These data offer valuable insights into the airport’s emissions trends and the relative contributions of different sources over time. A detailed analysis of this historical dataset reveals that Scope 2 emissions consistently represented the dominant portion of the airport’s total emissions under the Scope 1 and Scope 2 categories. This predominance is primarily attributable to electricity consumption, specifically from non-renewable energy sources—commonly referred to as “grey electricity”—which significantly impacted the airport’s overall carbon footprint during this period.

A pivotal development occurred in 2024, marking a major turning point in the airport’s sustainability trajectory. In that year, AHO Airport successfully completed its transition to the procurement of 100% renewable electricity, effectively eliminating Scope 2 emissions. This transition represents a critical milestone in the airport’s climate action plan, reflecting a strong commitment to energy decarbonization and resulting in a dramatic reduction of emissions to zero. The impact of this shift is substantial, as it fundamentally reshapes the emissions profile and sets a new baseline for future carbon reduction strategies.

With Scope 2 emissions now eliminated, attention has shifted more directly to Scope 1 emissions, which have become the primary source of the airport’s operational carbon footprint. Within this category, emissions from airport-owned vehicles now account for approximately 48%, making them the largest contributor, with the second contributor being Heating with 44% of total emissions in 2024. Refrigerant losses contribute around 6%, while the waste water treatment plant makes up the remaining 2%. These

findings underscore the importance of continuing to address direct emissions sources in order to build on the progress achieved so far.

This evolution in the structure of emissions not only reflects the effectiveness of the airport's decarbonization initiatives to date but also highlights the emerging priorities in its sustainability strategy. Looking ahead, further progress toward the airport's Net Zero target will require a concentrated effort to reduce Scope 1 emissions.

8 BASELINE CARBON FOOTPRINT

The baseline scenario offers a comprehensive projection of the anticipated evolution of Scope 1 and Scope 2 greenhouse gas (GHG) emissions from the reference year, 2024, up to the long-term target year of 2050. This projection is developed under the key assumption that no additional mitigation or decarbonization measures will be implemented beyond those already in effect as of 2024. In essence, it reflects a "Do nothing" scenario, where current technologies, energy sources, and operational practices remain unchanged over the coming decades.

The baseline scenario provides valuable insights into the natural trajectory of emissions in the absence of further climate action. It establishes a reference point against which all future reductions can be measured and assessed, allowing stakeholders to clearly understand the environmental implications of inaction. By visualizing what emissions levels will look like if the airport maintains the status quo, this scenario lays bare the gap between projected emissions and the desired Net Zero outcome.

Moreover, the baseline scenario plays a pivotal role in supporting decision-making and long-term sustainability planning. It helps to quantify the scale and urgency of the emissions reductions required to align with international and national climate targets. This understanding is essential for identifying high-impact intervention areas and for prioritizing investments in decarbonization initiatives such as clean energy, sustainable mobility, and infrastructure upgrades.

Ultimately, the baseline scenario acts as a strategic foundation for the airport's climate roadmap. It underscores the importance of immediate and sustained action, providing a clear contrast between a path of inertia and one of transformation. By highlighting the consequences of delayed action, it reinforces the need for a proactive and forward-looking approach to environmental management—one that ensures Alghero-Fertilia Airport contributes meaningfully to the global effort to limit climate change and achieve Net Zero emissions by 2050.

8.1 Assumptions and considerations

In developing the baseline scenario, several assumptions have been carefully considered to establish a realistic and data-driven projection of future developments at the airport.

Foremost among these is the expected significant growth in passenger traffic, consequently the growth in annual movements over the coming decades. Based on projections from the Pre-Master Plan, annual passenger volumes between 2040 and 2050 are anticipated to increase substantially, falling within a range of approximately 3 to almost 4 million passengers. This growth trajectory reflects broader trends in regional and international air travel demand and will inevitably place greater demands on airport operations, infrastructure, and associated emissions.

Concurrently, the evolution and expansion of airport infrastructure constitute another vital component shaping the baseline outlook.

The scenario takes into account a planned expansion in 2026 the following series of upgrades detailed in the "Piano della Tutela Ambientale", all targeted for completion by 2026:

- Expansion of the Schengen gates area,
- Additional 25 m² for boarding gates area,
- Expansion of the commercial and food court areas.

Moreover, a key assumption is the expansion of the airport in the year 2035 in order to sustain continuous traffic growth. Interventions which include:

- The expansion of the baggage claim area to accommodate higher passenger throughput,
- Enlargement of the departure lounge to improve passenger comfort and processing efficiency,
- And the introduction of a new swing gate facility.

These infrastructure enhancements are designed to optimize airport capacity and enhance the overall travel experience. However, it is important to note that while these improvements will support increased operational efficiency, they will also contribute to changes in the airport's energy consumption patterns and, consequently, its emissions profile.

At the end, as anticipated, this projection is based on the fundamental assumption that no further mitigation or decarbonization efforts will be introduced beyond the measures already in place as of 2024. **Essentially, it represents a "do nothing" scenario in which 2024 technologies, energy sources, and operational procedures continue unchanged throughout the coming decades.**

8.2 Conclusion "Baseline Scenario"

The graph reported below presents the projected CO₂ equivalent (CO₂e) emissions, measured in tons, for Alghero Airport over the studied period, under two distinct scenarios: the "Baseline Forecast" scenario, shown by the blue line, and the "Baseline Year Emissions" scenario, depicted by the grey spaced line. These scenarios provide a comparative outlook on how emissions may evolve depending on whether the airport maintains its current scale or experiences traffic and infrastructure growth.

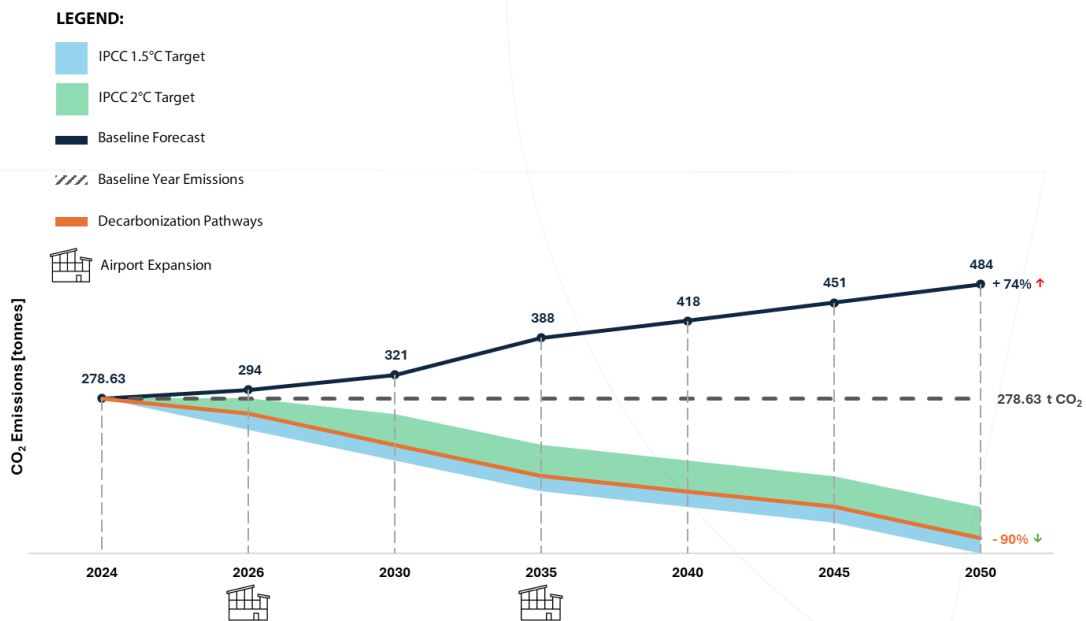


Figure 6: Baseline Emission Forecast

The blue and green areas in the graph represent the emissions reduction pathways necessary for the airport to stay in line with the global climate goals set by the Paris Agreement, aimed at limiting the average global temperature increase to 1.5°C (blue area) or, at most, 2°C (green area). This visual element serves as a reference for the level of ambition required to ensure compatibility with broader international climate targets.

In the base year of 2024, both scenarios begin at the same starting point of 279 tons of CO₂e. However, their trajectories quickly diverge. The "Baseline Year Emissions" scenario assumes that airport operations and passenger traffic remain relatively constant over the coming decades, resulting in stable emissions levels throughout the projection period.

In contrast, the "Baseline Forecast" scenario incorporates expected growth in airport activities, including increased passenger numbers, flights, and terminal expansion. Under this assumption, emissions are projected to rise gradually, reaching approximately 484 tons of CO₂e by 2050, which represents a 74% increase compared to 2024 levels.

This comparison clearly illustrates the impact of growth-related emissions on the airport's carbon footprint and emphasizes the urgency of implementing targeted decarbonization strategies to avoid exceeding climate-safe thresholds. It also reinforces the importance of integrating sustainability planning into future airport development and capacity expansion decisions.

The following graph presents the projected trend of total CO₂ emissions (in tons) for Alghero Airport from 2024 to 2050 in the baseline scenario, with a breakdown by Scope 1 and Scope 2 emissions. Total emissions are expected to rise from 279 tonnes in 2024 to 484 tonnes in 2050, reflecting anticipated airport growth without additional mitigation measures. Scope 1 emissions, primarily from vehicles and on-site fuel use,

make up the majority of the total, while Scope 2 emissions, attributable to purchased electricity, remain zero (with the assumption that 100% of the needed electricity is from a renewable source). The data emphasize the importance of addressing Scope 1 sources, particularly as electricity decarbonisation progresses, to effectively reduce the airport’s overall carbon footprint.

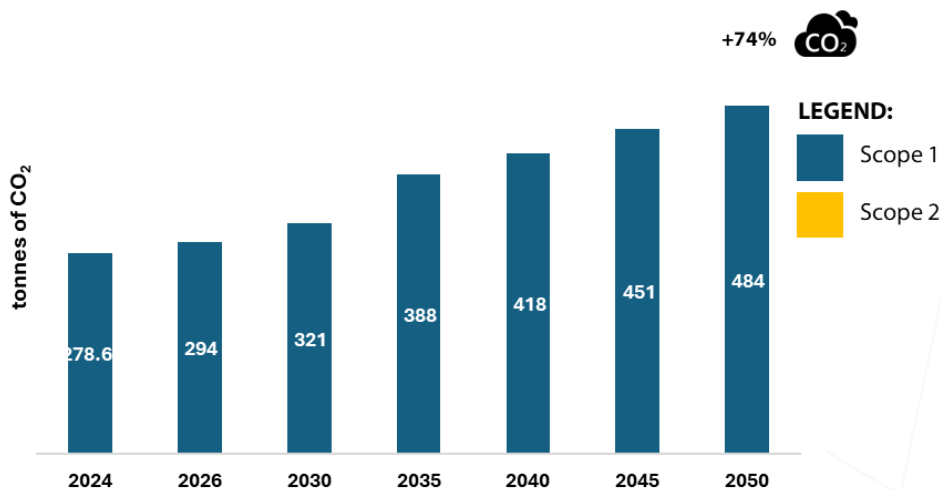


Figure 7: Baseline Forecast Emissions by Scope

The following figure presents a graphical representation of the percentage breakdown of CO₂ emissions by source at AHO from 2024 to 2050 of the “Baseline Forecast”. This scenario assumes no additional decarbonization measures. The chart provides insight into how the relative contributions of various emission sources are expected to evolve over time. In this scenario, emissions from airport-owned vehicles together with heating account for the largest shares. Vehicles starting from 48% in 2024 to an estimated 58% by 2050. This trend is primarily due to the projected growth in airport operations and associated ground transport needs, without the introduction of mitigation strategies such as electrification or alternative fuels. Heating, in 2024 accounts for 44% of the total Scope 1 and 2 emissions and by year 2050 it represents approximately 37%. The main factor contributing to heating is the expansion of the airport buildings (terminal and offices) over the years, to be able to accommodate the future growth in traffic.

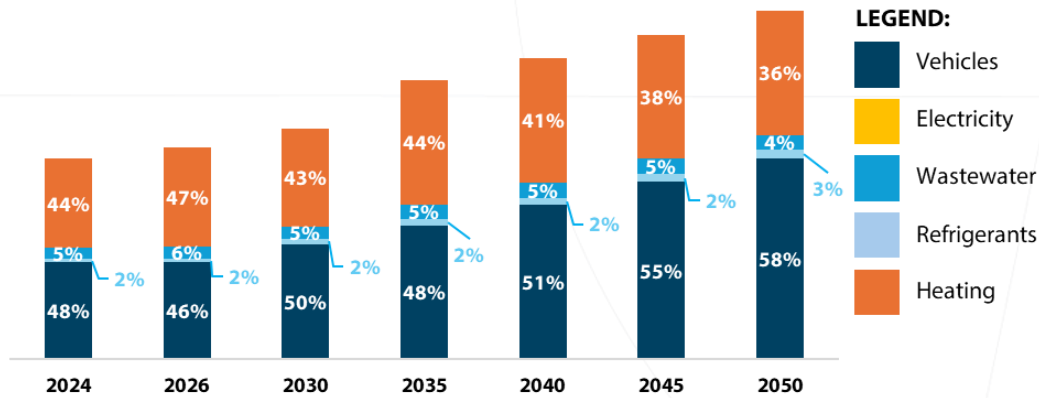


Figure 8: Baseline Split by Categories

Wastewater-related emissions contribute a relatively small (2%) but consistent portion throughout the period, indicating limited variation in this source. Similarly, the relative share of emissions from refrigerants remains constant over the years, which is between 4% to 6% of total emissions in each year.

This evolving emissions profile highlights a shifting landscape, where ground transport and heating will remain the dominant driver (>90% of the airport’s carbon footprint) in the absence of further action. As a result, it underscores the critical need for targeted mitigation measures in this area.

9 AIRPORT BENCHMARK

A comprehensive benchmarking analysis was carried out to identify a broad range of potential decarbonization measures applicable to the operations and infrastructure of Alghero Airport. This initial phase aimed to generate a long list of relevant actions, drawing on best practices, industry standards, and examples from comparable airports and transport hubs. The findings from this analysis provided a robust foundation for the next step in the process.

Each of the selected measures was carefully evaluated not only for its technical feasibility and alignment with airport operations, but also for its expected effectiveness in reducing emissions and its scalability within the context of Alghero Airport. This dual consideration ensures that the proposed actions are not only impactful in theory but also realistically implementable at the airport and at the pace required to meet climate goals. As a result of this analysis and dialogue with the Airport management, the original list was refined and prioritized, leading to the development of a shortlist of decarbonization measures, which is presented in the following section.








This shortlist primarily targets Scope 1 and Scope 2 emissions, which are directly attributable to airport operations. The focus on these categories reflects their central role in achieving the airport's Net Zero ambition, defined as a $\geq 90\%$ absolute reduction in CO₂e emissions in Scopes 1 and 2 by 2050 or earlier. The measures identified aim to address key emission sources such as vehicle fleets, heating systems, energy consumption, and refrigerant use.

However, while this current phase emphasizes Scope 1 and Scope 2, it is important to recognize the growing importance of addressing Scope 3 emissions that fall outside the airport's direct control but are influenced by its activities, such as passenger and employee travel, supply chain logistics, and airline operations. To holistically reduce the airport's climate impact, a clear commitment to tackling Scope 3 emissions will be essential by 2050 or sooner.

An initial selection of potential Scope 3 mitigation measures has also been identified and is referenced in a dedicated chapter regarding Scope 3, offering a foundation for future planning and broader stakeholder engagement as the airport advances along its decarbonization pathway.

Each measure has been assessed using the following criteria:

Table 3 - Decarbonisation Measures Key Performance Indicators

| Assessment criteria | |
|---|--|
|  | Location at airport <ul style="list-style-type: none"> Terminal Airside Landside |
|  | Typical emissions scope <ul style="list-style-type: none"> Scope 1 Scope 2 Scope 3 |
|  | Emissions impact Percent emissions (Reduction against typical business as usual technology/approach) |
|  | Implementation timeline Years (Related to technological maturity - Qualitative categorization) <ul style="list-style-type: none"> High: Fully commercialized and widely adopted technologies with proven track record Medium: Emerging technologies that are already in use but not widely adopted yet Low: Innovative or experimental technologies that are still in development or early-stage deployment |
|  | Financial viability <ul style="list-style-type: none"> Capital Expenditure (CAPEX) Operational Expenditure (OPEX) An indicative estimate has been derived from desktop research, including cited industry reports, relevant articles, and insights from development experience |
|  | Stakeholders to be involved <ul style="list-style-type: none"> Identified stakeholders that are affected by the measure in terms of decision making, implementation, and monitoring |
|  | Industry benchmark example <ul style="list-style-type: none"> Measures implemented at other airports |

9.1 Electrification of Ground Support Equipment (GSE)








Airside ground support equipment (GSE) and vehicles are an integral part of daily airport operations, performing a wide range of essential tasks that ensure the efficient and safe handling of aircraft on the ground. These activities include baggage handling, passenger transport between terminals and aircraft, aircraft pushback and towing, and refuelling operations, among others. Given the frequency and intensity of their use, GSE represents a significant source of direct (Scope 1) emissions, particularly when powered by diesel or other fossil fuels.

In this context, the adoption of electric ground support equipment (eGSE) presents a promising opportunity for decarbonization. eGSE eliminates emissions associated with internal combustion engines, offering a cleaner, quieter, and more energy-efficient alternative to conventional GSE. When powered by electricity

sourced from renewable energy, the emissions reduction potential of eGSE can reach up to 100%, making it a key strategy for achieving substantial progress toward Scope 1 emissions reduction targets.

It is important to note that a portion of the current GSE fleet is not presently eligible for electrification, due to the lack of available electric models on the market for certain specialized equipment types. As a precautionary assumption, it is estimated that approximately 10% of the fleet will remain non-electrifiable in the foreseeable future.

Table 4 - Electrification of Ground Support Equipment (GSE) - Key Performance Indicators

| | | |
|--|--|--|
|  <p>Location in airport: Airside, Landside</p> |  <p>Emissions impact: 90-100%</p> |  <p>CAPEX Estimate:</p> <ul style="list-style-type: none"> Purchase price 30-35% higher than petrol vehicles 9,000 € / charger <p>OPEX Estimate:</p> <ul style="list-style-type: none"> Potentially reduce by 100% the cost of petrol if electricity is generated on site Reduced maintenance cost by 35-45% per vehicle |
|  <p>Typical emissions scope: Scope 1</p> |  <p>Implementation timeline:</p> <ul style="list-style-type: none"> <u>Light commercial vehicles</u>: 2-5 years <u>Technological maturity</u>: high <u>Heavy duty vehicles</u>: 5-10 years <u>Technological maturity</u>: low |  <p>Stakeholders to be involved Airport fleet management department</p> |
|  <p>Industry benchmark example:</p> <ul style="list-style-type: none"> In 2015, Seattle-Tacoma Airport launched a \$45 Million programme to install nearly 570 electric vehicle charging points at every gate by 2021, aiming to reduce CO₂e emissions by 10,000 tonnes, and save nearly 1 Million gallons of petroleum annually². In 2019, Brussels Airport invested \$21 Million in thirty electric e-buses to transport passengers, saving around 600 tonnes of CO₂e annually³. Bergamo Airport is aiming to convert almost all of GSE to electric vehicles. | | |

² [Converting airport equipment to electric](#)

³ [Brussels Airport introduces electric buses to serve its passengers](#)

Table 5 - Electrification of Ground Support Equipment (GSE) – Advantages and Considerations

| Advantages | Considerations |
|--|---|
| <ul style="list-style-type: none"> Additional benefits include improved local air quality and reduced noise compared to combustible fuel alternatives. Lower refuelling costs and reduced exposure to petrol price fluctuations. | <ul style="list-style-type: none"> Upgrading airport electrical infrastructure may be necessary, potentially leading to high costs. Fleet battery recharging requirements may pose challenges for 24-hour airport operations, potentially requiring a larger fleet to accommodate charging rotations. |

9.2 Use of Low Carbon Fuels

Low carbon fuels (biofuels, HVO, etc.) play a key role in the transition to electrification, providing a lower-emission alternative for both stationary sources (such as generators) and mobile sources (vehicles, GSE). HVO is an effective solution for aircraft refuelling vehicles and other GSE where electric alternatives are not yet widely available. This includes tow trucks, self-propelled aircraft stairs, ground power unit, loaders, aircraft pushback vehicles, baggage belt loaders, cargo transporter, and air start units. HVO50 and HVO100 are types of renewable diesel derived from waste and residues (like animal fat, industrial waste, wastewater) making it a more sustainable option with up to 90% less emission compared to diesel.

Table 6 - Use of Low Carbon Fuels - Key Performance Indicators

| | | |
|--|---|--|
| Location in airport: Airside, Landside | Emissions impact: Up to 90% | CAPEX Estimate: N/A OPEX Estimate: Increase of 3-10% compared to fossil-based options |
| Typical emissions scope: Scope 1 | Implementation timeline: <2 years <u>Technological maturity: high</u> | Stakeholders to be involved Airport fleet management department |
| Industry benchmark example: <ul style="list-style-type: none"> London Heathrow Airport's fleet of 70 Heavy Goods Vehicles has switched to Hydrotreated Vegetable Oil (HVO), cutting the fleet's carbon footprint by 77% and reducing CO₂e emissions by over 2,400 tonnes annually⁴. Bergamo Airport is aiming to use HVO as an interim alternative to the complete GSE fleet electrification. | | |

⁴ [Biofuel switch for UK fleet cuts dnata's CO2 emissions by over 2,400 tonnes annually](#)

Table 7 - Use of Low Carbon Fuels – Advantages and Considerations

| Advantages | Considerations |
|--|---|
| <ul style="list-style-type: none"> • Can be used in existing diesel-powered equipment without modifications, enabling immediate adoption. • Reduces particulate matter and NOx emissions, contributing to a healthier airport environment. | <ul style="list-style-type: none"> • Global production capacity is still growing, and supply constraints may impact large-scale adoption. • While HVO is an effective interim solution, it should be integrated as part of a broader strategy that includes electrification for long-term sustainability. |

Planning recommendations

- Engage with OEM’s to validate compatibility and ensure seamless transition to HVO without performance issues
- Implement small-scale trials on various GSE to assess efficiency and operational reliability.




A promising development is on the horizon for Sardinia’s decarbonization efforts: the arrival of HVO100 (Hydrotreated Vegetable Oil) fuel supply on the island. In 2026, HVO100 is being distributed through service stations in Sardinia, starting with Mesu’e Rios in Chilivani, Sassari. This milestone signifies a major shift in local energy infrastructure, enabling businesses and operators across Sardinia to transition their existing diesel-powered vehicles, without engine modifications, to significantly lower-emission fuel.

Looking ahead, this initial rollout is expected to expand in coverage and availability, supported by broader trends in Italian and European investment in HVO production and distribution. As major refiners scale up HVO production and retrofit facilities in Sardinia and beyond, wider adoption appears increasingly feasible.

9.3 Heat Pumps

Heat pumps play a crucial role in the airport’s energy transition by providing efficient heating and cooling for terminal buildings and operational areas. Unlike traditional systems that rely on fossil fuels, modern heat pumps use electricity to transfer heat, significantly reducing direct emissions. When powered by renewable energy, heat pumps can virtually eliminate greenhouse gas emissions associated with climate control, offering an effective and sustainable solution for maintaining indoor comfort.

Table 8 - Heat Pumps - Key Performance Indicators

| | | |
|--|---|--|
|  Location in airport: Terminal |  Emissions impact: Up to 100% (if electricity used is 100% renewable) |  CAPEX Estimate: N/A (dependent on airport needs) OPEX Estimate: Potentially reduce by 100% the cost of petrol if electricity is generated on site |
|--|---|--|





| | | |
|---|---|--|
|  <p>Typical emissions scope: Scope 1</p> |  <p>Implementation timeline: <2 years Technological maturity: high</p> |  <p>Stakeholders to be involved Airport energy department</p> |
|  <p>Industry benchmark example:</p> <ul style="list-style-type: none"> In 2024, Portland International Airport received a \$6 million grant to replace its fossil fuel-powered terminal heating system with an electric-powered heat pump. This upgrade is projected to reduce the airport’s energy required for heating and cooling by 83% and significantly cut greenhouse gas emissions, demonstrating how large-scale adoption of heat pumps at airports can drive both operational efficiency and substantial climate benefits ⁵. Bergamo airport planned to introduce this measures in its net zero roadmap. | | |

Table 9 - Heat Pumps – Advantages and Considerations

| Advantages | Considerations |
|--|--|
| <ul style="list-style-type: none"> Heat pumps can reduce energy usage up to 50% compared to conventional HVAC systems, leading to significantly lower utility bills and operational costs over time for large facilities like airports. Heat pumps can reduce CO₂ emissions and improve local air quality, especially when renewable electricity is used. | <ul style="list-style-type: none"> The initial costs for purchasing and installing heat pump systems can be higher than traditional systems, and proper sizing, design, and placement are crucial to ensure optimal performance and avoid operational issues. |

9.4 Use of Very Low GWP Refrigerants

Very low global warming potential (GWP) refrigerants, such as R1234yf, are essential in reducing the climate impact of cooling systems at airports. These next-generation refrigerants offer a sustainable alternative to traditional high-GWP substances, significantly lowering direct greenhouse gas emissions from air conditioning and refrigeration units. R1234yf, for example, has a GWP of less than 1 making it an ideal choice for terminal HVAC systems, cold storage, and catering facilities.

⁵ [FlyPDX - Oregon Delegation Announces an Additional \\$6 Million for Major Energy Efficiency Upgrades at PDX](#)

Table 10 - Use of Very Low GWP Refrigerants - Key Performance Indicators








| | | |
|--|--|--|
|  Location in airport: Terminal |  Emissions impact: >90% less emissions compared to traditional refrigerants |  CAPEX Estimate: N/A OPEX Estimate: <ul style="list-style-type: none"> • Small increase in price compared to traditional refrigerants |
|  Typical emissions scope: Scope 1 |  Implementation timeline: <2 years Technological maturity: high |  Stakeholders to be involved: Airport management department |
|  Industry benchmark example: <ul style="list-style-type: none"> • In 2019, Gatwick Airport completed the UK's first installation of an ultra-low GWP chiller using Carrier's AquaForce 30XAV system with PUREtec HFO R-1234ze refrigerant, which has a GWP rating of less than 1. This project was part of Gatwick's broader environmental strategy to transition away from high-GWP refrigerants, reduce carbon emissions by 50%, and improve energy efficiency. The new chiller not only delivers significant reductions in the airport's carbon footprint and running costs, but also integrates seamlessly with existing building systems, demonstrating how switching to very low GWP refrigerants can help airports achieve ambitious sustainability targets while maintaining operational resilience and flexibility⁶. | | |

Table 11 - Use of Very Low GWP Refrigerants – Advantages and Considerations

| Advantages | Considerations |
|---|--|
| <ul style="list-style-type: none"> • Very low GWP refrigerants, such as R1234yf, dramatically reduce the climate impact of cooling systems, helping airports lower their direct greenhouse gas emissions and comply with evolving environmental regulations. • These refrigerants are often compatible with modern, high-efficiency HVAC and refrigeration equipment, supporting energy savings and long-term sustainability goals. | <ul style="list-style-type: none"> • The transition to very low GWP refrigerants may require the replacement or significant modifications of existing equipment, which can involve upfront investments and operational downtime. • Special handling, training and updated safety protocols may be necessary, as some low GWP refrigerants have different flammability or chemical properties compared to traditional refrigerants. |








By adopting very low GWP refrigerants, airports can achieve substantial reductions in their overall carbon footprint, support compliance with evolving environmental regulations, and contribute to the aviation industry's broader decarbonisation goals.

⁶ [Case study - Gatwick Airport Ultra Low GWP | Carrier Europe](#)

9.5 Efficiency of Wastewater Treatment Plant

The efficiency of wastewater treatment plants plays a key role in reducing greenhouse gas emissions at airports. Aerobic and anaerobic processes influence both the amount and type of GHG release into the atmosphere (such as CO₂), which can have a significant impact on the airport's total emissions. Measures like the optimization of biological treatment, the recovery of biogas and reduction in organic load at the source are essential for the improved performance of the sewage treatment plant and the minimization of the climate impact.

Table 12 - Efficiency of Wastewater Treatment Plant – Key Performance Indicators

| | | |
|--|--|--|
|  <p>Location in airport: Landside</p> |  <p>Emissions impact: Up to 30%</p> |  <p>CAPEX Estimate: N/A OPEX Estimate: • Small increase in maintenance costs and staff trainings</p> |
|  <p>Typical emissions scope: Scope 1</p> |  <p>Implementation timeline: <2 years <u>Technological maturity</u>: high</p> |  <p>Stakeholders to be involved: Airport management department</p> |
|  <p>Industry benchmark example:</p> <ul style="list-style-type: none"> Frankfurt Airport (FRA) operates its own fully biological wastewater treatment plant, integrated with municipal systems, to handle sewage and airport runoff efficiently. This includes advanced biological processes to maintain effluent quality.⁷ Tri-Cities Airport (PSC) implemented an innovative worm-based biodynamic aerobic sludge system (BioFiltro) to treat deicing wastewater, reducing biochemical oxygen demand (BOD) as well as emissions.⁸ San Francisco International Airport (SFO) developed a Zero Waste Plan that includes co-digestion of organic waste with wastewater sludge at its treatment plant, reducing organic load and generating renewable energy.⁹ | | |

⁷ [Water Management Case Study at Frankfurt Airport](#)

⁸ [Tri-Cities Airport Puts Worms to Work to Treat Deicing Wastewater - Airport Improvement](#)

⁹ [San Francisco International Airport \(SFO\) - Stok](#)

Table 13 - Efficiency of Wastewater Treatment Plant - Advantages and Considerations

| Advantages | Considerations |
|--|---|
| <ul style="list-style-type: none"> Optimizing biological treatment can significantly reduce CO₂ emissions by improving aerobic efficiency and capturing biogas, supporting airports in meeting sustainability targets. Operational condition control (e.g. maintaining temperature, oxygen and microbial balance) enhances treatment stability and ensures compliance with environmental regulations. Reducing the organic load at the source lowers the burden on treatment plants, cutting energy use and operational costs while minimizing emissions from methane and other CO₂ equivalent greenhouse gasses. | <ul style="list-style-type: none"> Implementing advanced biological optimization or biogas recovery may require capital investments and infrastructure upgrades. Source reduction measures often depend on coordination with airport stakeholders, which can be complex to manage. Continuous monitoring and skilled staff are essential for maintaining operational efficiency and avoiding performance issues. |

9.6 On-site Solar PV

Solar photovoltaic (PV) panels capture sunlight and convert it into electricity, offering a clean and renewable energy source. These systems can be installed on rooftops, car park canopies, or ground-mounted structures, making them highly adaptable to available space. Depending on the system's capacity and configuration, excess electricity can be stored in batteries, allowing for use during periods of low solar generation or to help manage peak demand more efficiently.

Table 14 - On-Site Solar PV - Key Performance Indicators

| | | |
|---|--|---|
| Location in airport: Airside, Terminal, Landside | Emissions impact: Up to 100% | CAPEX Estimate: ~ 360€/sqm OPEX Estimate: 0.016€/W |
| Typical emissions scope: Scope 2 | Implementation timeline: 2-5 years <u>Technological maturity</u> : medium | Stakeholders to be involved Airport Sustainability Department, Technical Services |
| Industry benchmark example: <ul style="list-style-type: none"> Rome Fiumicino Airport inaugurated in January 2026 Europe's largest airport solar farm with a power of 22MWp, which extends for almost 2.5km and will contribute to reducing the airport's CO₂ emissions by over 11,000 tons per year.¹⁰ | | |

¹⁰ [ADR: Rome Fiumicino Airport's new Solar Farm](#)

- Denver International Airport in the United States operates multiple solar farms with a combined capacity exceeding 10 megawatts, significantly reducing its carbon footprint and lowering electricity costs¹¹.
- Bergamo airport has planned to install PV panels inside the airport boundary area.

Table 15 - On-Site Solar PV - Advantages and Considerations

| Advantages | Considerations |
|---|--|
| <ul style="list-style-type: none"> • Mature technology for solar PV, Battery storage technology continuously evolving and systems becoming cheaper. • Scalable to meet anticipated electrical demand and available space. • Low maintenance and a typical lifespan of +25 years. • Using battery storage improves energy supply resilience. | <ul style="list-style-type: none"> • Limited to the availability of space for installation. • Weight of PV panels may necessitate additional structural reinforcement for roof-mounted installations. • Large spatial provision for battery storage. required. Typically, a 40ft shipping container houses 1MWh of storage. |

Planning recommendations:

- Assess the airport’s energy demand profile to determine supply and demand requirements.
- Compare the airport’s energy consumption patterns with projected PV generation, including battery storage potential.
- Conduct a safety assessment before implementation, including glint and glare analysis to prevent interference with aviation operations.

At Alghero Airport, plans are underway to install a 40 kWp solar panel. This initiative is designed to enhance the airport’s energy self-sufficiency, reduce exposure to electricity market price fluctuations, and ensure that the energy used is 100% green. In addition to supporting sustainability goals, the investment in solar infrastructure is expected to deliver long-term economic returns, contributing to both operational resilience and financial efficiency.

¹¹ [Considerations for Airport Solar Farms](#)

10 DECARBONISATION PATHWAYS

To define a suitable decarbonisation pathway for Alghero Airport, it is essential to conduct a comprehensive evaluation of various scenarios for each major emission source. This process involves analysing not only the high-level technical feasibility of available solutions but also assessing their performance in the context of economic conditions, anticipated technological developments, and the evolving regulatory and policy landscape at the regional, national, and international levels.

Each scenario reflects different assumptions regarding the pace of innovation, market trends, funding availability, and the stringency of future environmental regulations. By simulating and comparing multiple trajectories, it becomes possible to better understand the range of options available, and the trade-offs associated with each.

By integrating the insights from these scenarios, flexible and adaptive decarbonization pathways that respond to uncertainty and changing priorities over time can be developed. These pathways help identify the most effective measures to implement in the short, medium, and long term, depending on the targeted level of emissions reduction, the cost-efficiency of interventions, and the infrastructure readiness of the airport.

10.1 Emission Reduction Scenarios

An overview of the decarbonisation scenarios for category (Vehicles, Heating, Refrigerants, Wastewater and Electricity) is presented in the following table. Each scenario outlines how the respective emission sources are developed in the final stage of the roadmap, corresponding to the year 2050.

The objective is to define two distinct pathways: one that minimizes CAPEX, and another that prioritizes the earliest possible achievement of net-zero emissions.






Table 16 - Overview Decarbonisation Scenarios – 2050 horizon

| Scenario | Vehicles | Heating | Refrigerants | Electricity | Waste Water |
|---------------------------------------|----------------------------|-----------------|--|--|---------------------------------|
| Baseline (reference year 2024) | 99% Diesel 1% Gasoline | 100% Diesel | Use of: R-407C | 100% Purchased green electricity | No water reduction measures |
| Pathway 1 | 70% Electric 30% Diesel | 100% Heat pumps | Transition to R-1234yf instead of R-407C | 98.5% Purchased green electricity 1.5% PV | 20% rate for reduction measures |
| Pathway 2 | 90% Electric 10% HVO | 100% Heat pumps | Transition to R-1234yf instead of R-407C | 100% PV | 20% rate for reduction measures |

10.2 Measures Legend

In the following table a short description of the icons used in the graphs are explained.

Table 17 - Legend for Carbon Reduction Measures

| Icon | Definition |
|---|---|
|  | Electrification of Ground Support Equipment and personnel transportation. |
|  | On-site electricity production (Solar PV) |
|  | Transition to heat-pumps for the terminal heating and cooling system |
|  | Use of very low GWP Refrigerants |
|  | Water conservation measures and efficiency of the treatment plant. |

10.3 Emission Reduction Pathways

The previous results informed the development of the forecast scenarios shown in the following figure.

The graph illustrates different emissions pathways aligned with the Paris Agreement's 1.5°C and 2°C warming limits. The Paris Agreement's 1.5°C pathway (green) represents the most ambitious target, aiming for net-zero emissions by 2050 with at least a 90% reduction from the baseline. The 2°C pathway (blue) reflects a more moderate reduction, with emissions declining more gradually and net-zero reached by 2060.

The results from the preceding analysis provided the foundation for developing the forecast scenarios illustrated in the figure below. These scenarios depict a range of potential emissions reduction trajectories, each aligned with internationally recognized climate targets under the Paris Agreement, which aims to limit the rise in global average temperature to well below 2°C, and ideally to 1.5°C, above pre-industrial levels.

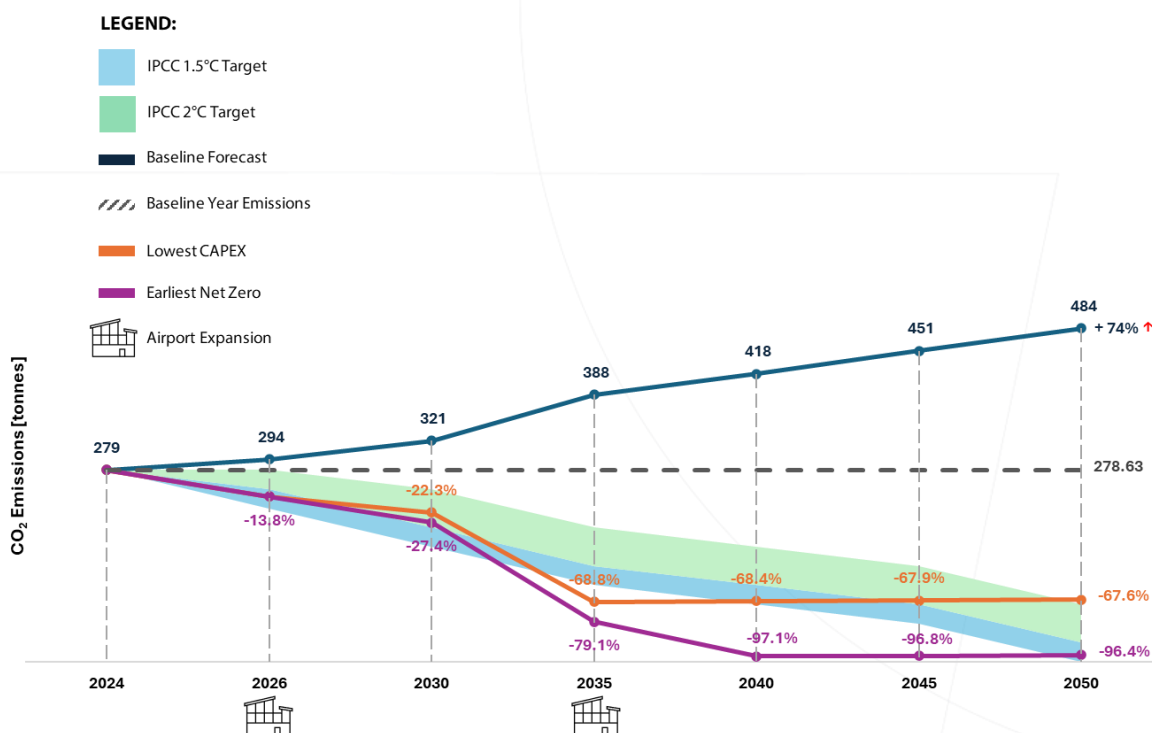


Figure 9: Evolution of Pathways

In the subsequent sections, each of these emissions pathways will be examined in detail.

10.3.1 Pathway 1 – Lowest CAPEX

In the Lowest Capex scenario (referred to as Lowest CAPEX), the airport embarks on a cost-effective decarbonization pathway that unfolds over several distinct phases through 2050. All measures outlined in this pathway are initiatives already scheduled by AHO for implementation until year 2030, as referenced in various sustainability documents. These measures will be elaborated in greater detail below.

Beginning with the vehicle fleet, the transition assumes that 38% of the current vehicles will be electrified, with all future vehicle purchases being fully electric. This trajectory leads to a steady increase in electric fleet share, ultimately stabilizing at 70% electric penetration by 2050. This shift marks a significant move toward low-emission ground mobility, while the remaining 30% diesel share reflects legacy assets gradually phased out over time

In parallel, the heating and cooling sector undergoes a full transformation in 2035: all systems are converted to heat pumps, existing buildings are systematically retrofitted, and refrigerant systems are overhauled with no top-ups until 2040, after which leakage becomes effective. This ensures the complete transition to efficient, low-GWP climate control.

Regarding electricity supply, an optimized strategy is adopted combining purchased green electricity and on-site generation. In 2026, a small solar panel park is built on the airside are of the airport bringing the mix to 98% procured renewable energy and 2% generated via solar PV. These shares are maintained throughout

the years. It is important to note that Alghero Airport has already transitioned to purchasing **100% green electricity in 2024**, thus all Scope 2 emissions are currently zero. While adding photovoltaic panels will not alter the emissions trajectory, it will enhance circular sustainability and reduce reliance on outsourced energy.

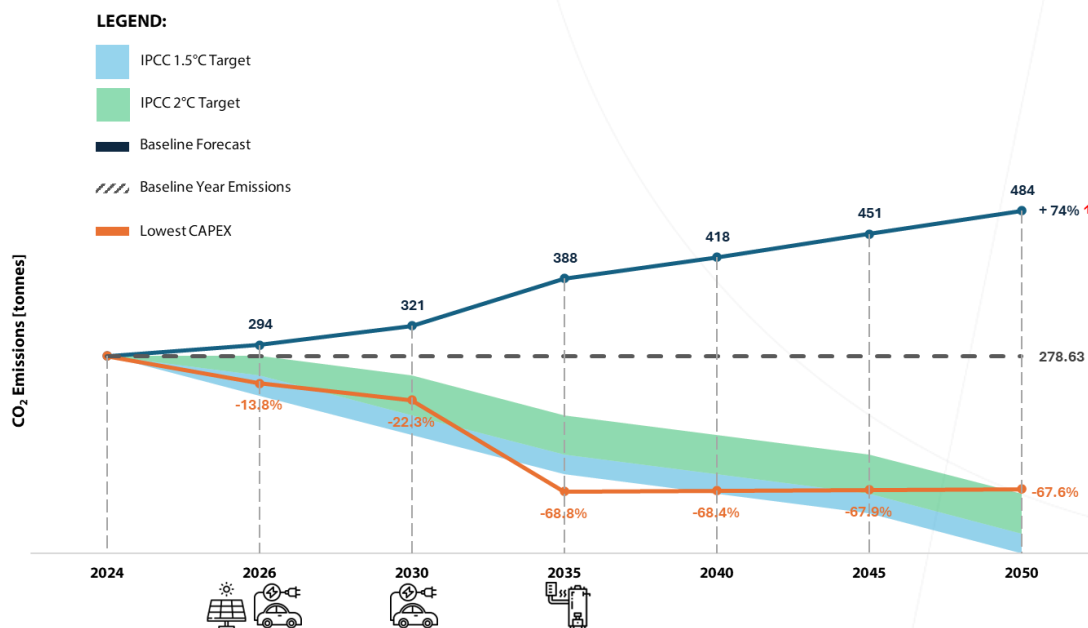


Figure 10: Pathway 1 – Lowest CAPEX timeline

Collectively, this structured, low-capital expenditure (“Lowest Capex”) pathway leverages established, cost-effective technologies, such as electric vehicles, heat pumps, building retrofits, enhanced refrigerant management, and solar PV installations, to steadily drive down emissions while keeping upfront investment requirements modest. By focusing on proven and scalable solutions, the airport can progress towards decarbonization without large immediate financial outlays.

However, it is crucial to acknowledge that this approach alone does not achieve the ultimate Net Zero emissions target by 2050. Without additional and higher-cost interventions the airport cannot fully eliminate residual emissions. Therefore, while this pathway lays a solid foundation and generates meaningful emissions reductions at reasonable cost, supplementary, more ambitious measures will be essential in the coming decades to ensure compliance with the Paris-aligned 1.5 °C trajectory and to secure genuine Net Zero outcomes by mid-century.

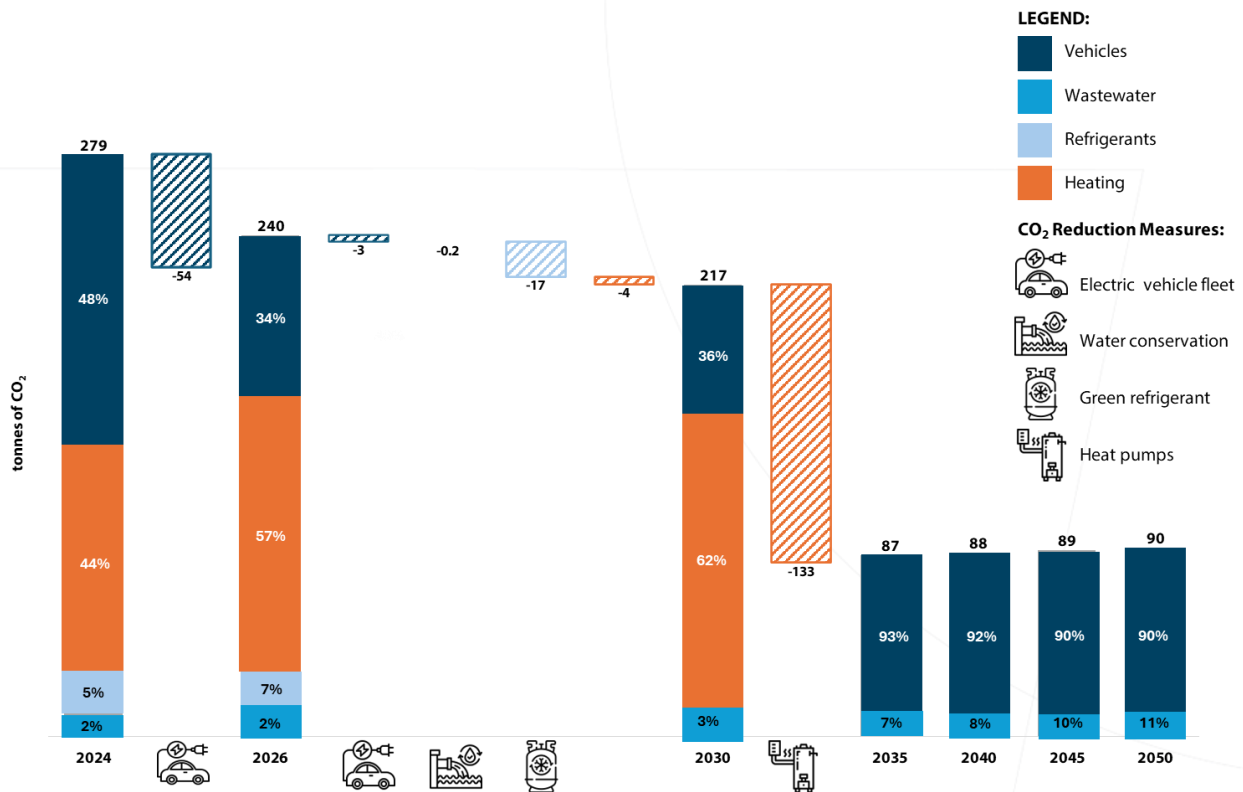


Figure 11: Pathway 1 – Distribution and Evolution of CO₂ by Categories

The figure above illustrates the projected decline in total emissions from 2024 to 2050, with emissions falling from 279 tons to 90. In 2024, emissions are divided among vehicles (48%), heating (44%), refrigerants (5%) and wastewater (2%). By 2035, vehicles account for 93% and wastewater for 7% of total emissions, as other sources such as heating are eliminated by the transition to heat pumps. The data highlights significant progress in reducing emissions from heating and refrigerants, while vehicle emissions remain the main contributor over the long term.

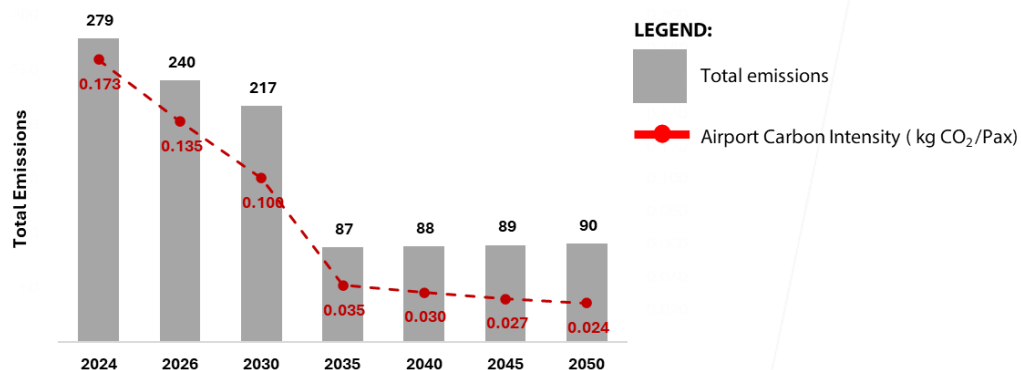


Figure 12: Forecast of Airport Carbon Intensity

10.3.2 Pathway 2 – Earliest Net Zero

In the Earliest Net Zero scenario (referred to as Pathway 2), the airport pursues an accelerated, ambitious decarbonization strategy, targeting the net zero carbon emissions well before 2050. This approach unfolds through a series of targeted interventions across vehicles, heating, cooling, and electricity systems, as illustrated in the graph.

The transition to an electric vehicle fleet (>90% including the majority of the GSE) is prioritized from the start, with significant electrification of the fleet and with the remaining of the 10% GSE transitioned to using a low emission carburant (HVO50 or HVO100). Key milestones are marked in 2026 (38% electric vehicles), 2035 (71% electric vehicles), and 2040 (90% electric vehicles), indicating ongoing upgrades to electric vehicles and sustained reductions in vehicle-related emissions.

At the same time, the heating and cooling sector undergoes a complete overhaul: all systems transition to heat pumps, existing buildings are thoroughly retrofitted, and refrigerant systems are revamped with no refilling needed until 2040, after which leakage control measures become fully effective and low GWP refrigerants are used in order to ensure continued emission reductions.

In this pathway, AHO increases the share of self-produced renewable electricity, with an initial planned investment in 2026 and an additional photovoltaic park in 2040 (the airport will be able to fully meet its electricity needs with self-produced renewable energy). These include the expansion of on-site renewable generation, such as solar PV installations.

Since Alghero Airport already sources 100% green electricity, its Scope 2 emissions are currently zero and are expected to remain so through the 2050 target year, as the airport reaffirms its commitment to maintaining this important achievement.

At the same time, the installation of additional PV panels will not affect the emissions trajectory; rather, it will enhance circular sustainability and reduce dependence on external energy supply. In this pathway,

different scenarios for additional PV capacity are therefore considered and described in the following chapters.

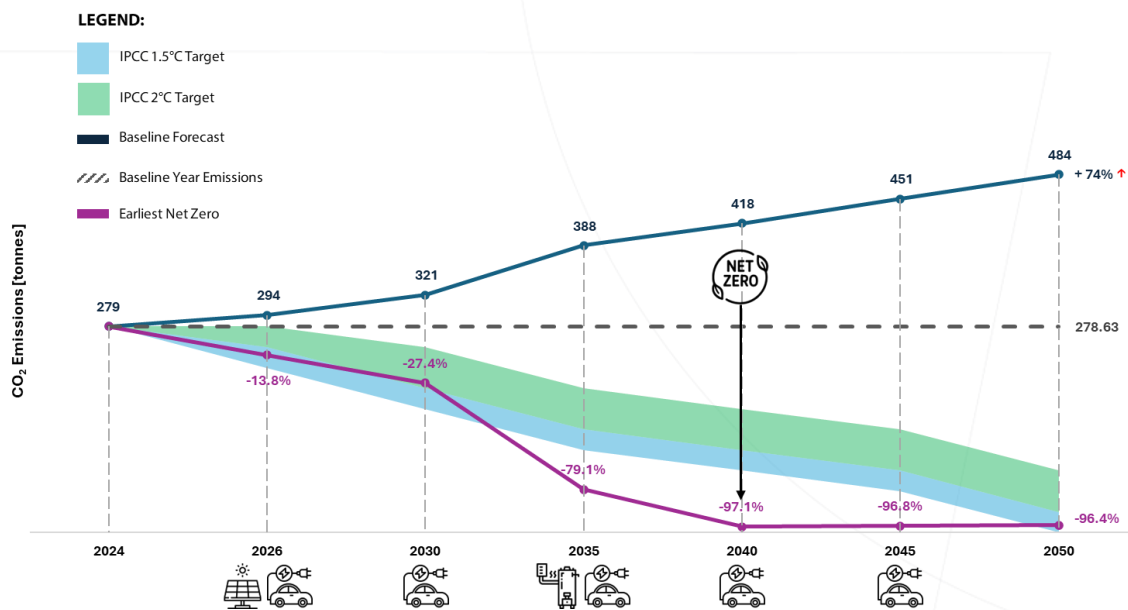


Figure 13: Pathway 2 Timeline

In the Figure above it is observed that the pathway achieves a dramatic reduction in CO₂ emissions, with an 79% decrease by 2035 compared to the baseline. By 2040, a 97.1% reduction is achieved—reaching the net zero threshold. After reaching net zero in 2040, emissions remain at minimal levels, with an approximate 97% reduction maintained until 2050.

The emissions trajectory is below the 1.5°C target range, as indicated by the shaded area on the graph, ensuring compliance with international climate commitments.

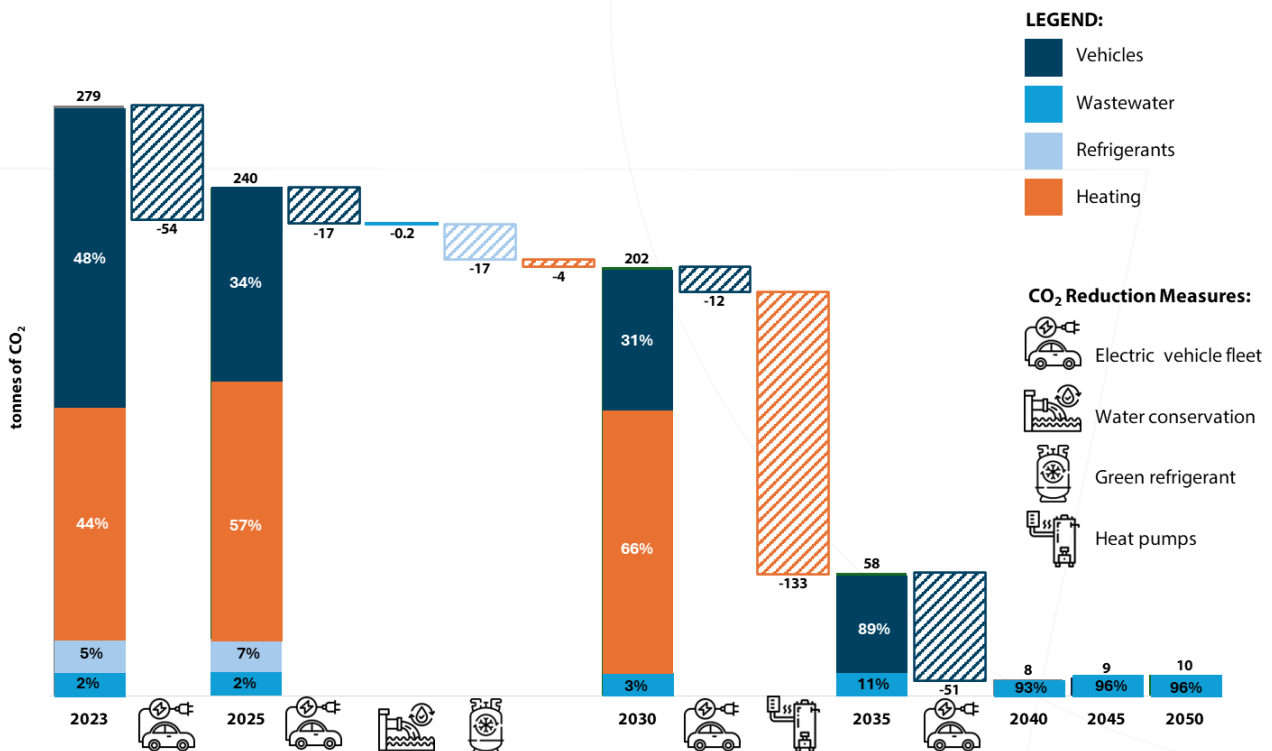


Figure 14: Pathway 2 – Distribution and Evolution of CO₂ Emissions by Categories

This graph shows a dramatic reduction in total emissions from 2024 to 2050, with emissions dropping from 279 tons to as low as 8 tons of CO₂. In 2024, emissions come mainly from vehicles (48%) and heating source (44%), with the remaining 7% split between refrigerant leaks and wastewater treatment. In 2030 and 2035, vehicles contribute significantly, making up 92% and 89% of the total respectively. From 2040 onwards, vehicle emissions are almost eliminated due to the transition to electric GSE and the transition to HVO for the non-electric fleet. The majority contributor is the Wastewater treatment plant, which by 2050 accounts for 96%.

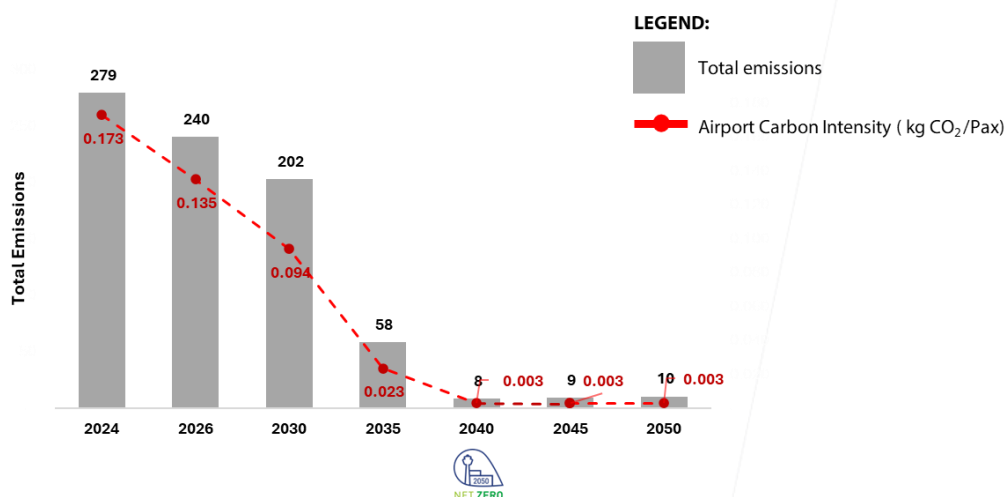


Figure 15: Forecast of Airport Carbon Intensity













11 Key Performance Indicators (KPI's)

KPIs are crucial for effectively monitoring progress and should be aligned with financial instruments to ensure consistency between sustainability goals and financing strategies. The following section provides an overview of global sector-specific KPI definitions.

11.1 Global sector-specific KPI's

First published in June 2020, the Sustainability-Linked Bond Principles (SLBP) provide guidelines that recommend structuring features, disclosure, and reporting practices for sustainability-linked bonds. To support implementation, the SLB Working Group released an Illustrative KPIs Registry¹², developed based on a materiality matrix that identifies the most material sustainability themes for each sector. Building on this framework, the table below presents selected KPIs for the aviation sector, specifically for the airport subsector. In addition to sector-specific KPIs, some cross-sector KPIs were also included to better reflect AHO's decarbonisation measures. The KPI Registry ensures that KPIs are aligned with key sustainability themes and the United Nations Sustainable Development Goals (SDGs). Moreover, global benchmarks for KPI definition highlight initiatives and frameworks that provide content and guidance to support the definition and implementation of these metrics.

Table 18 - KPI's derived from the 2024 SLBP Illustrative KPI Registry

| Category | KPIs | SDGs | Global Benchmarks for KPI Definition |
|--------------------------|--|---|--|
| GHG Emissions and Energy | Absolute energy consumption (GWh/year) |    | GRI 302 |
| GHG Emissions and Energy | Proportion of renewable energy used against total energy consumption (%) |    | IEA World Energy Outlook IRENA RE100 |
| GHG Emissions and Energy | Scope 1, 2, and 3 GHG emissions (intensity or absolute) (tCO ₂ , kgCO ₂ e/pax) |   | - |
| Waste | Percentage of waste recycled or otherwise recovered in an environmentally sustainable way (%) |  | GRI (306-4) |
| Waste | Total weight of waste generated (t/year) |  | GRI (306-4) |
| Water | Proportion of reused/recovered/recycled water |   | CDP Water Security GRI (303-3) |

¹² [Sustainability-Linked Bond Principles \(SLBP\) » ICMA](#)

12 COST CONSIDERATIONS

In this chapter, the operative costs (OPEX, Operational Expenditure) and the ones related to the investments planned (CAPEX, Capital Expenditure) are presented.

12.1 Capital Expenditure (CAPEX)

The values presented in the following figure serve as reference points for CAPEX estimates. These costs are informed by a combination of benchmarking studies and internal technical analyses, resulting in preliminary CAPEX estimations.

As the Baseline pathway serves as a reference point without any new measures implemented, the CAPEX remains at zero throughout all years. This constant zero CAPEX in the Baseline scenario provides a benchmarking against which the financial impacts of other pathways can be compared.

12.1.1 Pathway 1 – Lowest CAPEX

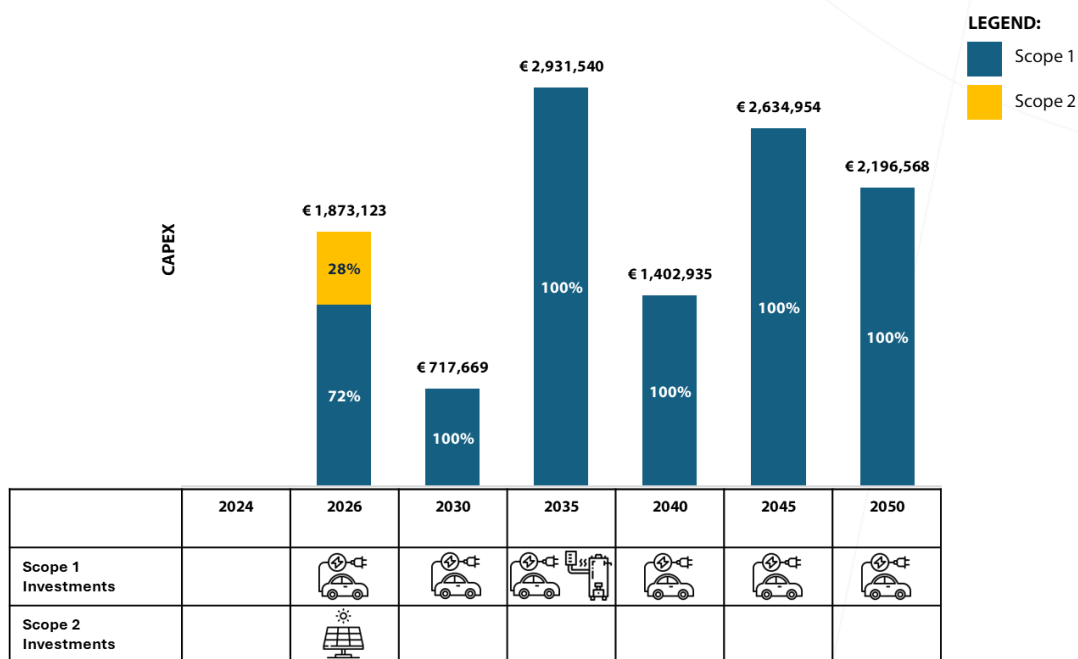


Figure 16: CAPEX - Pathway 1

In Pathway 1, capital expenditures (CAPEX) associated with Scope 2 emissions are limited and highly focused. The only notable Scope 2 CAPEX arises from the implementation of a photovoltaic park in 2026.

The forecasted number of vehicles is based on aircraft movement trends for ground support equipment and projected growth in personnel for staff vehicles and is further described in the table below.

Table 19: Lowest CAPEX - Forecasted numbers for the vehicle fleet

| Year | 2024 | 2026 | 2030 | 2035 | 2040 | 2045 | 2050 |
|------------------------------|------|------|------|------|------|------|------|
| Total fleet | 47 | 47 | 56 | 65 | 75 | 86 | 97 |
| Additional purchase vehicles | 0 | 0 | 9 | 8 | 10 | 11 | 11 |
| Electric fleet | 18 | 18 | 28 | 36 | 46 | 57 | 68 |

For the year 2026, Scope 1 accounts for 72% of the total CAPEX, amounting to approximately €1.8 million. This significant investment is allocated as follows:

- for electric Ground Support Equipment (GSE): In 2026, expenditures for electric vehicles amounted to €1.34 million.

From 2030, the only investments come from Scope 1, more specifically the continuous purchase of the electric GSE fleet. A notable investment is in 2035 which is the installation of the heatpumps for the HVAC system, which is purchased in 2030 for €1.08 million.

As operational activity grows, the airport must acquire additional electric vehicles to ensure efficient ground handling and passenger service. Consequently, the incremental CAPEX for Scope 1 is solely attributed to the purchase and deployment of new electric GSE units, reflecting the direct relationship between fleet size and service demand.

No other significant Scope 2 capital investments are planned under this scenario. The strategy prioritizes cost-effective decarbonization, relying on existing infrastructure for electricity supply and limiting new expenditures to those strictly required by operational growth.

12.1.2 Pathway 2- Earliest Net Zero

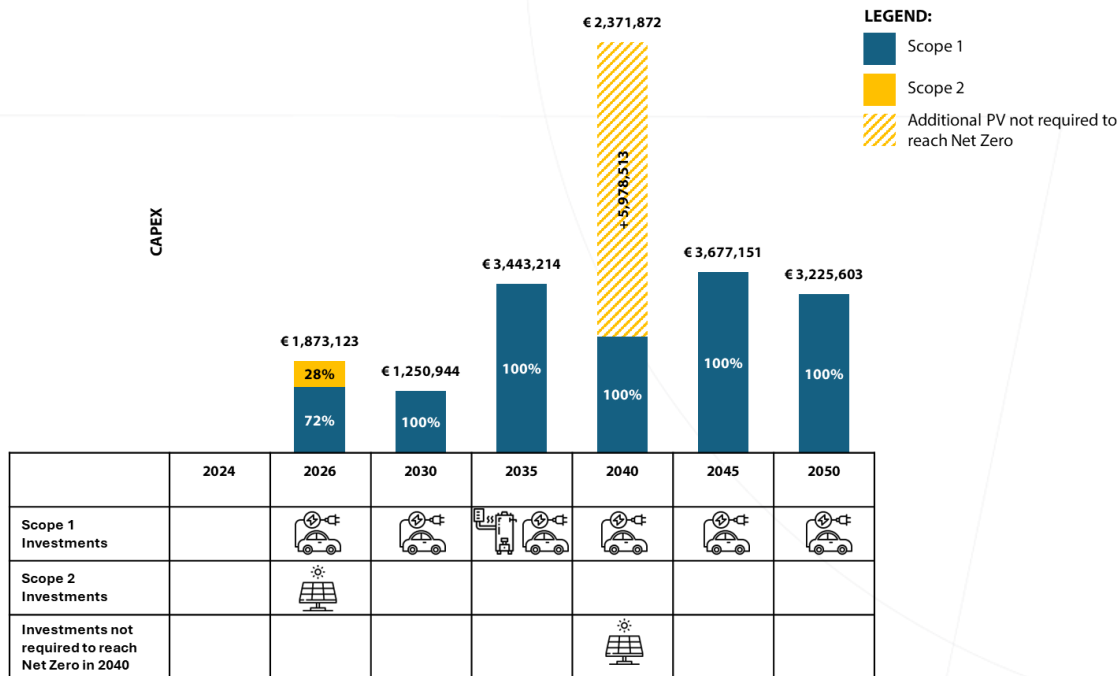


Figure 17: CAPEX – Pathway 2

The graph illustrates the capital expenditure (CAPEX) required to achieve Net Zero emissions under **Pathway 2**, highlighting investments across Scope 1 and Scope 2 emissions. The timeline shows that the airport’s decarbonization strategy involves significant and strategically timed investments, particularly in vehicle electrification and infrastructure upgrades. Early investments in 2024 and 2026 amount to €1.87 million and €2.33 million respectively, with 2026 including a notable share of Scope 2 spending (28%) for an on-site PV . From 2030 to 2035, CAPEX is around €1.3 million and €2.3 million, respectively, and is fully dedicated to Scope 1 measures such as vehicle electrification and heat pumps implementation.

A key observation occurs in 2040, where CAPEX reaches €2.37 million for mandatory investments, but the graph also displays a hatched section representing an additional €5.98 million for photovoltaic (PV) installations. This hatched portion is explicitly marked as “not required to reach Net Zero,” meaning that producing 100% of electricity on-site through solar panels is optional. The airport can achieve its Net Zero target without incurring this extra cost, relying instead on a combination of Scope 1 electrification and necessary Scope 2 upgrades. This distinction underscores that while renewable energy generation can enhance sustainability, it is not a prerequisite for compliance with Net Zero objectives.

Beyond 2040, investments stabilize again, with €3.68 million in 2045 and €3.23 million in 2050, both fully allocated to Scope 1 initiatives. This strategy positions the airport to achieve deep decarbonization and meet ambitious climate objectives well ahead of 2050, while maintaining financial prudence through targeted, high-impact capital investments.

The forecasted number of vehicles is based on aircraft movement trends for ground support equipment and projected growth in personnel for staff vehicles and is further described in the table below.

Table 20: Earliest Net Zero - Forecasted numbers for the vehicle fleet

| Year | 2024 | 2026 | 2030 | 2035 | 2040 | 2045 | 2050 |
|------------------------------|------|------|------|------|------|------|------|
| Total fleet | 47 | 47 | 56 | 65 | 75 | 86 | 97 |
| Additional purchase vehicles | 0 | 0 | 9 | 8 | 10 | 11 | 11 |
| Electric fleet | 18 | 18 | 33 | 46 | 61 | 77 | 87 |

For the year 2026, Scope 1 accounts for 72% of the total CAPEX, amounting to approximately €1.34 million.

This significant investment is allocated as follows:

- for electric Ground Support Equipment (GSE): In 2024, expenditures for electric vehicles.

Additional significant investments can be seen in 2030 where:

- For Heat Pumps: investments related to the installation of heat pumps totaled €1.08 million.

12.2 Operational Expenditure (OPEX)

In order to project and develop the OPEX trends for the future, all the costs related to the day-by-day expenses are needed. Some of them are extremely difficult to estimate due to their uncertainty in the future and, for this reason, several assumptions must be imposed. From this viewpoint, it follows that:

- **Vehicles:** the OPEX for vehicles is calculated by adding the maintenance costs to the product of annual consumption (for GSE and Personnel), the number of vehicles, and the current fuel price. For electric vehicles, only the maintenance cost is included under the vehicles category, while the electricity consumption and its corresponding cost (in place of fuel) are accounted for in the electricity category.
- **Heating:** OPEX in this category is only applicable to the baseline forecast, where it is calculated by multiplying the number of Liters of diesel consumed by the current diesel price. As with vehicles, the OPEX related to energy consumption for heat pumps is included in the electricity category.
- **Refrigerants:** the annual amount of coolant used in the forecast is determined as a ratio between the amount used in the baseline year and the surface of the building in the baseline year and current year. A price factor in €/kg based on Italy current prices for refrigerants is used to determine the OPEX.
- **Waste Water:** the annual OPEX is calculated as the total amount of wastewater in Liters produced multiplied by a factor = $0.2\text{€}/\text{L}^{13}$.
- **Electricity:** the OPEX is an estimation based on the forecasted demand of electricity in kWh and a factor of $0.016\text{€}/\text{W}^{14}$.

¹³ [Cost of Urban Wastewater Treatment and Ecotaxes: Evidence from Municipalities in Southern Europe](#)

¹⁴ [U.S. Solar Photovoltaic System and Energy Storage Cost Benchmarks, With Minimum Sustainable Price Analysis: Q1 2024](#)

12.2.1 Pathway 1 – Lowest CAPEX

The graph below shows the projected evolution of the airport’s operating expenses (OPEX) from 2024 to 2050, segmented by Scope 1 and Scope 2 emissions. Over time, total OPEX remains stable ranging from €0.98 million to €1.2 million. The composition of these expenses shifts as well: while Scope 2 (primarily related to purchased electricity) consistently represents the majority of costs.

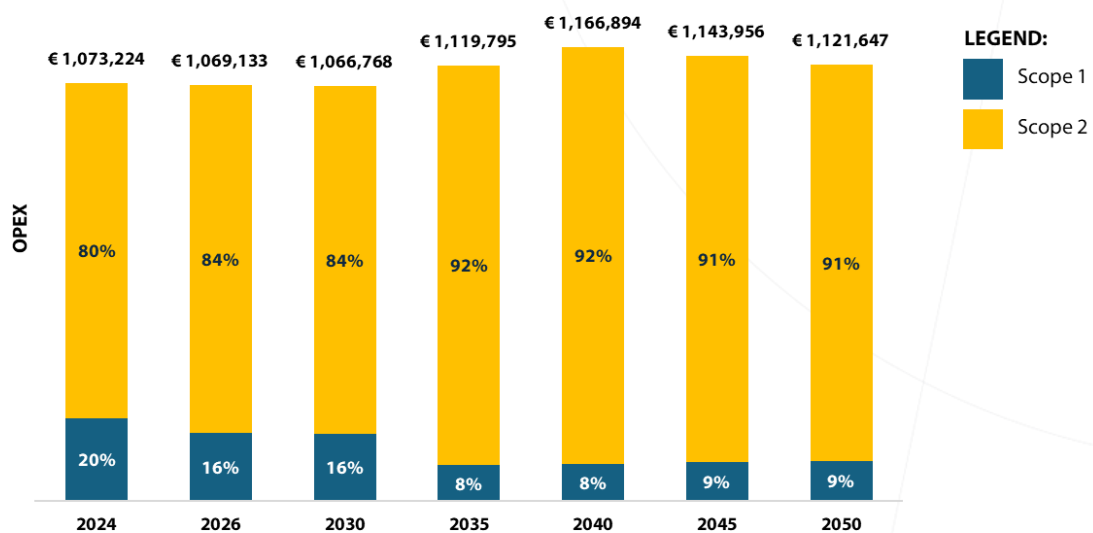


Figure 18: OPEX - Pathway 1

12.2.2 Pathway 2 – Earliest Net Zero

The graph below presents a detailed projection of the airport’s operating expenses (OPEX) from 2024 through 2050 under Pathway 2, which represents an accelerated decarbonization strategy. OPEX is segmented into Scope 1 (direct emissions from airport-controlled sources) and Scope 2 (indirect emissions from purchased electricity), allowing a clear view of how cost structures evolve alongside emissions reductions.

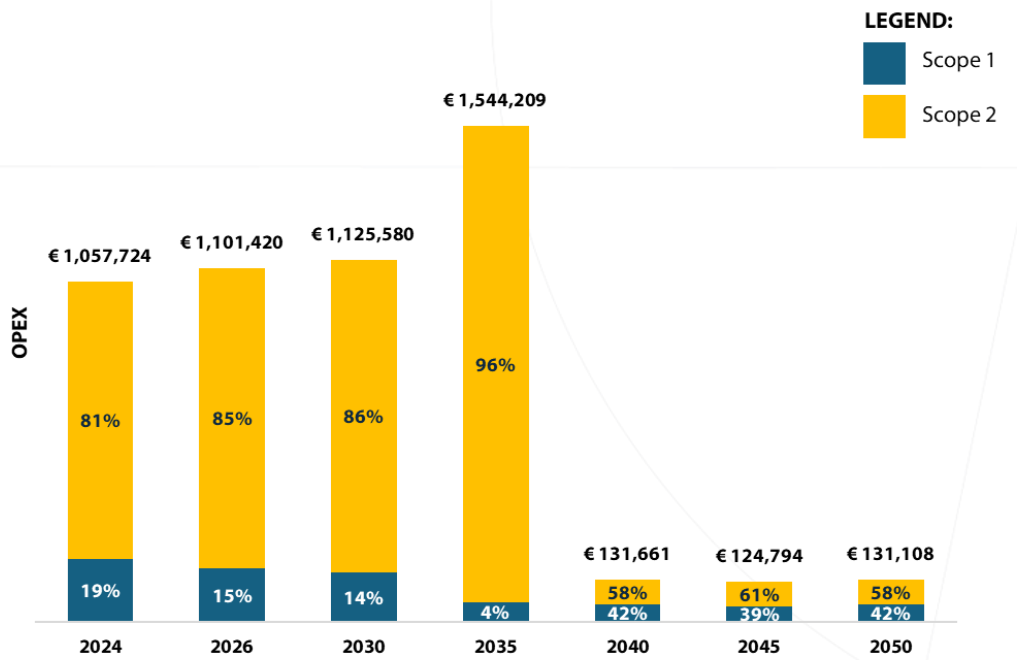


Figure 19: OPEX - Pathway 2

A notable trend in Pathway 2 is the shifting balance between Scope 1 and Scope 2 expenses. While Scope 2 remains the dominant component until 2040, its share decreasing to 58% of the total OPEX. This shift reflects the airport's transition away from externally sourced energy towards greater control over direct emissions, as on-site renewables and electrification reduce dependency on purchased electricity.

13 OFFSETTING

The described decarbonisation measures will have a large impact in achieving a net-zero for Alghero Airport. However, there are certain emissions that are not possible to be mitigated through normal measures and will therefore have to be compensated through offsetting measures.

Table 21 - CO₂e Abatement Required per Pathway

| Pathway/ Year | 2026 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|------|------|------|------|------|------|
| CO ₂ e abatement required (t) to achieve carbon neutrality / net-zero | | | | | | |
| Pathway 1 | 240 | 217 | 87 | 88 | 89 | 90 |
| Pathway 2 | 240 | 202 | 58 | 8 | 9 | 10 |

Only the most established and credible offset programmes that meet strict methodological and quality criteria are eligible under Airport Carbon Accreditation. A list of eligible offsetting programmes can be found in the programme's Offset Guidance Document¹⁵. These include the Verified Carbon Standard, Gold Standard, Climate Action Reserve, and others. In order to ensure that offsets are of high quality they should meet the following criteria:

- **Real:** Reductions/removals must have already occurred and be proven.
- **Additional:** Reductions/removals wouldn't have occurred without the project and offset revenue.
- **Measurable:** Reductions/removals must be quantifiable with minimal error.
- **Verifiable:** Third-party auditor must verify reductions/removals under set standards.
- **Permanent:** Measures must prevent reversal of reductions; safeguards needed for high-risk projects.
- **Unique:** Reductions/removals can't be claimed or registered more than once.

Direct Air Capture (DAC) and Bio sequestration were identified as potential offsetting measures. DAC is an example of an engineered offset removal method, meaning it is a human-developed process to capture and store ambient GHG emissions. Bio-sequestration is an ecosystem-based method, meaning it makes use of naturally occurring processes to increase the uptake and storage of GHG emissions in carbon sinks, generally those based on land but also including oceans.

While both approaches show strong potential for long-term carbon removal, it is important to acknowledge the risk of reversals, particularly with nature-based solutions. Reversals refer to the potential re-release of sequestered carbon due to factors such as land-use change, environmental degradation, or extreme weather events. To mitigate this risk, the selection of specific projects should include a thorough evaluation of the implementer's risk mitigation strategy to ensure the permanence of carbon sequestration.

13.1 Direct Air Capture (DAC)

DAC is a technology that removes CO₂ from the atmosphere. It works by using large fans to pull ambient air into the system, where chemical filters, such as amine-based or solid sorbents, bind with the CO₂ molecules. The captured CO₂ is then heated and released, allowing it to be either stored underground through carbon

¹⁵ [Offset Guidance Document](#)

sequestration or used to create Sustainable Aviation Fuel (SAF). The cost of DAC typically ranges between 100\$¹⁶ to 1000\$¹⁷ per ton of CO₂ captured.

For AHO, the emergence of Direct Air Capture technologies offers a promising pathway for offsetting residual emissions on the journey to Net Zero. While DAC is still in the early stages of deployment in Italy, several national and European initiatives are advancing the technology. For example, Italian energy companies¹⁸ and research institutions are collaborating on pilot DAC facilities¹⁹ capable of capturing several tons of CO₂ per year directly from the atmosphere. These efforts are supported by EU funding²⁰ and align with Italy's broader climate strategy to scale up carbon removal solutions. As DAC technology matures and becomes more widely available.

13.2 Bio sequestration

Bio sequestration is a nature-based offsetting measure that involves capturing and storing atmospheric carbon dioxide through biological processes such as afforestation, reforestation, soil carbon sequestration, and wetland restoration.

Bio sequestration projects offer a credible and effective way to compensate for residual emissions that cannot be eliminated through direct operational improvements. By investing in high-quality, certified bio sequestration initiatives, such as forest restoration or soil carbon enhancement, the airport can contribute to long-term carbon removals, support biodiversity, and deliver co-benefits for local communities. This approach aligns with the requirements and recommendations of Airport Carbon Accreditation²¹, which encourages airports to prioritize robust, permanent, and transparent offset removals as part of their Net Zero strategies.

¹⁶ [Direct Air Capture](#)

¹⁷ [A comparative look at Direct Air Capture and CO2 capture from biogas upgrading - Nordsol](#)

¹⁸ [Eni & Snam Launch Italy's First Carbon Capture & Storage for Gas Plant | EnergyTech](#)

¹⁹ [Climeworks direct air capture plant in Italy](#)

²⁰ [CarpeCarbon Direct Air Capture Plant Design Receives \\$1.9M Funding - Carbon Herald](#)

²¹ [Environmental Policy](#)

14 SCOPE 3

Scope 3 emissions are indirect greenhouse gas (GHG) emissions that occur as a consequence of an organization's activities but arise from sources not owned or directly controlled by the organization. For airports, Scope 3 emissions are particularly significant, as they encompass a broad range of activities across the aviation value chain, including those associated with passengers, staff, and third-party operations.

14.1 ACA Levels of Influence, Guide, and Control in Scope 3 Emission Reduction

The Airport Carbon Accreditation (ACA) framework provides a structured approach for airports to address emissions based on their varying levels of authority over different emission sources. Emissions are categorized according to whether the airport can control, guide, or influence them.²²

- **"Control"** applies to emissions from activities the airport directly manages, such as its own vehicle fleet or on-site energy use.
- **"Guide"** refers to emissions from operations where the airport can set standards or provide direction, such as ground handling services or certain tenant activities.
- **"Influence"** covers emission sources where the airport's role is primarily to encourage or facilitate change, for example, emissions from airline operations or passenger travel to and from the airport.

Understanding and applying these levels is essential for effective Scope 3 emission reduction. By distinguishing between what can be controlled, guided, or influenced, airports can develop targeted strategies, ranging from implementing operational mandates to fostering partnerships and advocacy efforts. This tiered approach ensures that all relevant emission sources are addressed appropriately, allowing airports to maximize their contribution to Scope 3 reductions and support their overall net zero ambitions.²³

14.2 Scope 3 Decarbonisation Measures

14.2.1 Fixed Ground Power Units (GPU) and Pre-conditioned Air (PCA)

Many large aircraft rely on an auxiliary power unit (APU) to supply onboard lighting, electronics, and air conditioning while parked at the gate. This eliminates the need to start the main engines during passenger boarding and preparation. However, APUs consume approximately 150 litres of aviation fuel per hour, generating substantial CO₂e and particulate emissions, along with noise and air quality impacts.

To reduce reliance on APUs, Fixed Electrical Ground Power and Pre-Conditioned Air systems allow aircraft to connect directly to the local grid or airport-based renewable energy sources (see initiatives on onsite solar PV, battery energy storage, and purchasing renewable energy).

²² [Short-Guide-to-Airport-Carbon-Accreditation-November-2020.pdf](#)

²³ [7 levels of accreditation - Airport Carbon Accreditation](#)

Table 22 - Fixed Ground Power Units (GPU) and Pre-conditioned Air (PCA) - Key Performance

| Indicators | | |
|--|--|--|
| Location in airport: Airside | Emissions impact: Reductions of up to 50% in APU emissions | Stakeholder to involve: Ground Handlers Airlines |
| <div style="text-align: center;"> </div> <p>Industry benchmark example:</p> <ul style="list-style-type: none"> • Hong Kong International Airport invested \$7.8 million to provide fixed electrical ground power (FEGP) and pre-conditioned air (PCA) at all stands and enforced a ban on APU use at frontal stands, leading to a 20% reduction in NOx emissions between 2017 and 2018²⁴. • Heathrow Airport invested \$36.5 million by 2018 to implement FEGP and PCA, fitting over 90% of its stands with FEGP to reduce APU use²⁵. | | |

Table 23 - Fixed Ground Power Units (GPU) and Pre-conditioned Air (PCA) - Advantages and Considerations

| Advantages | Considerations |
|---|--|
| <ul style="list-style-type: none"> • Enhanced local air quality and lower noise levels compared to APU usage. • Decreased aircraft fuel consumption and related emissions. • Greater control for AHO over energy usage. • Opportunity to further reduce Scope 2 emissions when powered by renewable energy sources. | <ul style="list-style-type: none"> • Upgrading airport electrical infrastructure may be necessary. • Less practical for aircraft with short turnaround times. • If powered by on-site renewables, battery storage may be needed to manage peak electricity demand and ensure availability during low-generation periods. • Collaboration with stakeholders is essential, as airlines may prefer APU use. |

Planning recommendations

- Determine the need for pre-conditioned air at each bay based on typical aircraft usage and turnaround times.
- Evaluate space availability for installation and integration with centralized power unit (if applicable) to enhance system efficiency.
- Analyse the impact of increased electrical demand on existing infrastructure.

²⁴ [Carbon Reduction Programme, Environment - Hong Kong International Airport](#)

²⁵ [2024_FY_HAHL_ARA_Final.pdf](#)

Role of airport:

To enforce adoption, the airport must collaborate with airlines and ground handling service providers, implement usage policies, and potentially introduce incentives or regulations to encourage compliance.





ACA Level:

For fixed GPU and PCA systems, the airport typically achieves the "guide" level of authority under the ACA framework. While airports may not directly operate all aircraft or ground handling equipment, they can set requirements or provide infrastructure for airlines and service providers to use fixed electrical ground power and pre-conditioned air instead of aircraft auxiliary power units. By mandating or incentivizing the use of these systems, airports play a guiding role, establishing standards and facilitating adoption to reduce emissions during aircraft turnaround.

14.2.2 Sustainable Aviation Fuels (SAF)

SAF is produced from various organic materials such as sugarcane bagasse, molasses, wood waste, animal fats, vegetable oils, and agave. AHO can support the transition to biofuels by ensuring its fuel delivery infrastructure is compatible. In many cases, SAF can be integrated into existing fuel pipelines, including blended with conventional jet fuel as an interim solution. By establishing the necessary infrastructure, AHO can further encourage biofuel adoption by eliminating internal or contractual barriers to its use.

Table 24 - Sustainable Aviation Fuel (SAF) - Key Performance Indicators

| | | |
|---|---|--|
|  <p>Location in airport: Airside</p> |  <p>Emissions impact: Reduction of up to 80% per gallon</p> |  <p>Stakeholder to involve: Fuel Provider Airlines Ground Handlers Civil Aviation Authority (ENAC)</p> |
|  <p>Industry benchmark example:</p> <ul style="list-style-type: none"> Royal Schiphol Group allocated €15 million for SAF promotion from 2022 to 2024, offering subsidies of €500 per tonne of SAF and €1,000 per tonne of synthetic fuels²⁶. SEA Milano has committed €500 per tonne of SAF blended with fossil fuel for airlines at Linate and Malpensa airports, with €450,000 allocated for 2024 and €500,000 committed for 2024²⁷. | | |

²⁶ [Schiphol announces rise in airport charges as an incentive for use of SAF](#)

²⁷ [Sustainable Aviation Fuels \(SAF\) and other Alternative Fuels Used for Aviation | European Alternative Fuels Observatory](#)

Table 25 - Sustainable Aviation Fuel (SAF) - Advantages and Considerations

| Advantages | Considerations |
|---|---|
| <ul style="list-style-type: none"> • Potential for substantial reductions in Scope 3 emissions by decreasing reliance on fossil fuels. • Compatibility with existing pipelines and fuel infrastructure enables easier integration. • Opportunity to utilise organic waste as a feedstock, including materials from on-site airport waste management processes, reducing the need for virgin resources. | <ul style="list-style-type: none"> • SAF costs remain higher than conventional jet fuel and can vary significantly based on the feedstock used. • The sustainability impact of SAF differ: Some production methods generate high greenhouse gas emissions or contribute to environmental issues like deforestation. • Clear governance and ownership responsibilities must be established for delivering biofuel through existing fuel hydrant infrastructure. |

Planning recommendations

- Assess the necessary infrastructure to support SAF usage, including integrating SAF into existing pipelines or developing new ones.
- Explore opportunities to encourage SAF adoption through contractual agreements and consider renegotiating aviation fuel supply contracts to include biofuel options.

Role of airport

The airport plays a key role in providing the necessary infrastructure for SAF, such as dedicated storage tanks and fuelling systems. To enforce adoption, the airport must work closely with airlines, fuel suppliers, and ground services to ensure SAF availability at the airport, while also collaborating with regulators to implement incentives, such as discounted landing fees or preferential treatment for airlines that commit to using SAF.

ReFuelEU Aviation:

The EU ReFuelEU Aviation incentive is a cornerstone policy in the European Union’s net zero roadmap, designed to accelerate the decarbonization of the aviation sector. As part of the broader Fit for 55 package, this regulation mandates a progressively increasing share of sustainable aviation fuels (SAF) in aviation fuel supplied at EU airports, starting at 2% in 2026 and rising to 70% by 2050.²⁸

The initiative aims to create a level playing field for air transport across Europe, stimulate innovation and investment in SAF production, and drive down costs through economies of scale. By harmonizing SAF mandates across all member states, the ReFuelEU Aviation regulation provides market certainty and reduces compliance complexity for airlines and fuel suppliers. Additional incentives include direct financial support through EU Emissions Trading System allowances, preferential tax treatment for SAF, and support for research and development. Collectively, these measures are expected to deliver substantial reductions

²⁸ [ReFuelEU Aviation - European Commission](#)

in aviation emissions, foster job creation, and ensure that sustainable fuels become widely available, supporting the EU’s ambition to achieve net zero emissions by 2050.²⁹





ACA Level:

The airport’s role in promoting Sustainable Aviation Fuel (SAF) adoption is primarily at the "influence" level. Airports do not control the fuel choices of airlines but can encourage SAF uptake by facilitating supply, supporting fuel infrastructure, and engaging with airlines and fuel providers. Their ability to influence is crucial: through partnerships, incentives, and advocacy, airports can foster a market for SAF and help drive industry-wide change toward net zero goals.

14.2.3 Aircraft Upgrades

Aircraft design continually evolves to enhance fuel efficiency, reduce emissions, and lower operating costs. Advancements include more efficient engines, lightweight materials, and improved aerodynamics. AHO can support these innovations by ensuring that its runways, taxiways, support services, and terminals are equipped to accommodate both current and next-generation aircraft.

Table 26 - Aircraft Upgrades - Key Performance Indicators

| | | |
|---|--|---|
|  Location in airport: Airside |  Emissions impact: Fuel consumption of new aircraft designs can be reduced by approximately 15-25% |  Stakeholder to involve: Airlines Ground Handlers |
|  Industry benchmark example: <ul style="list-style-type: none"> Brisbane Airport’s 2020 Master Plan recognises changes in designs of aircraft that are currently being manufactured and the demands these aircraft will place on the airside infrastructure³⁰. | | |

²⁹ [RefuelEU Aviation Regulation](#)

³⁰ [Airport Master Plan | Brisbane Airport](#)

Table 27 - Aircraft Upgrades Advantages and Considerations

| Advantages | Considerations |
|---|--|
| <ul style="list-style-type: none"> Airport master planning provides an opportunity to anticipate future aircraft needs, helping to minimize emissions and avoid the costs associated with retrofitting infrastructure. | <ul style="list-style-type: none"> Uncertainty in predicting future aircraft trends and requirements. Airports have limited influence over the embodied energy, design, and operation of aircraft. |

Planning recommendations

- Work closely with airlines to align airport infrastructure with their future fleet plans and sustainability commitments.
- Offer reduced landing fees, preferential slots, or other benefits for airlines that operate newer, low-emission aircraft or retrofit existing fleets with greener technology.
- Collaborate with airlines, manufacturers, and government bodies to promote tax benefits, grants, or rebates for aircraft upgrades and the adoption of cleaner technologies.

Role of airport

The airport plays an important role in ensuring that its runway, taxiways, support services, aprons, and terminals are designed and maintained to accommodate both current and next-gen aircrafts. Examples of these include enhancing taxiway layouts, future-proofing terminal facilities for emerging aircraft types, or integrating new fuelling systems. The airport must collaborate with airlines, aircraft manufacturers, ground handlers, and aviation regulators to ensure these upgrades are made in line with evolving aircraft designs, safety standards, and operational efficiency goals.

ACA Level:

When it comes to aircraft upgrades, such as the adoption of newer, more efficient aircraft or retrofitting existing fleets, the airport’s authority is at the **"influence"** level. Airlines retain full control over their fleets, but airports can support upgrades by offering incentives, preferential slots, or collaborating on environmental initiatives. By influencing airline decisions through policy, collaboration, and recognition programs, airports contribute indirectly to emission reductions.

14.2.4 Surface access improvements

Airport surface access refers to the non-aviation travel to and from the airport by passengers, visitors, and staff. Enhancing airport surface access and promoting low-emission transport options can help reduce emissions and ease congestion. Potential improvements include public transport hubs, dedicated electric vehicle parking and charging stations, and road redesigns such as express lanes for electric vehicles.

Table 28 - Surface Access Improvements - Key Performance Indicators





| | | |
|--|--|--|
|  Location in airport: Landside |  Emissions impact: For example, the electric metro reduces emissions by approximately 85% per vehicle kilometre compared to a petrol car |  Stakeholder to involve: Public Transport providers Local governments |
|  Industry benchmark example: <ul style="list-style-type: none"> In 2018, Perth Airport began construction on infrastructure for a new train station near Terminal 1, including the Skybridge, a 280m elevated walkway with travellators, to promote greater public transport use³¹. Manchester Airport’s Sustainable Development Plan 2016 includes a Surface Access Plan. The Plan recognises the importance of partnerships to influence surface access improvements³². | | |

Table 29 - Surface Access Improvements - Advantages and Considerations

| Advantages | Considerations |
|--|---|
| <ul style="list-style-type: none"> Reduced local traffic congestion, leading to lower emissions. Enhanced safety by minimising transportation conflicts. Broader benefits for local and regional communities. Opportunity to promote electric vehicle adoption through charging infrastructure powered by renewable energy. Potential to integrate with future transport infrastructure developments. | <ul style="list-style-type: none"> Implementation may require coordination and approval from government and transport authorities. Funding agreements between airports, government, and transport authorities may be necessary. |

Planning recommendations

- Assess passenger travel patterns to and from the airport, identifying carbon emissions by transport mode.
- Integrate surface access enhancements into broader transport master plan.
- Collaborate with transport authorities to coordinate necessary infrastructure upgrades.

Role of airport

³¹ [Perth Airport](#)

³² [Sustainable Development Plan](#)

The airport is responsible for providing infrastructure that supports low-emission transportation. For that, the airport must initiate conversations with local governments and transport providers to establish specific initiatives.

ACA Level

Improvements to surface access (such as public transport links, cycling infrastructure, or electric vehicle charging), airports generally operate at both the **"guide"** and **"influence"** levels. Airports can guide by investing in on-site infrastructure, setting access policies, and collaborating with local authorities and transport providers. Their influence extends to encouraging passengers and staff to use low-carbon transport options through incentives, awareness campaigns, and partnerships. Achieving net zero requires airports to leverage both guidance and influence to transform how people access the airport, reducing associated Scope 3 emissions.

15 NET ZERO ROADMAP

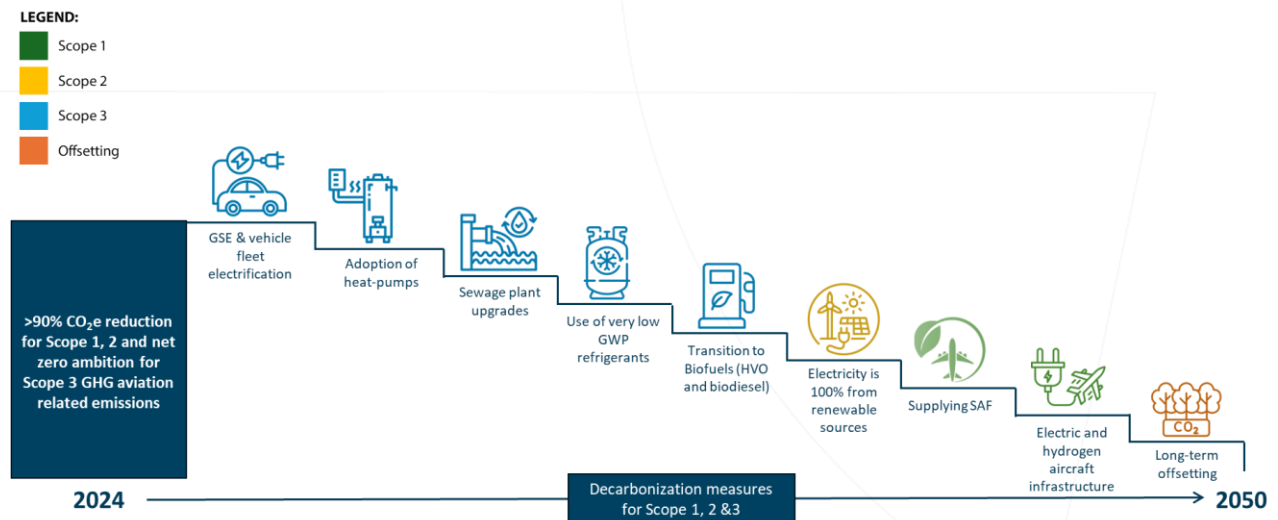


Figure 20: Net Zero Roadmap Measures

The roadmap culminates with long-term carbon offsetting strategies to address any residual emissions that cannot be eliminated through operational changes or technological upgrades. This comprehensive, phased approach demonstrates a commitment to continuous improvement and innovation, aligning with international climate goals and ensuring a significant reduction in environmental impact across all emission sources.

Scope Coverage

- **Scope 1 (Direct Emissions):** Actions such as fleet electrification and refrigerant management directly reduce on-site emissions.
- **Scope 2 (Indirect Emissions):** Energy efficiency and renewable energy initiatives target emissions from purchased electricity and heat.
- **Scope 3 (Other Indirect Emissions):** Efforts like sustainable aviation fuel adoption and carbon offsetting address broader value chain emissions, including those related to air travel.

This roadmap serves as a strategic guide for organizations aiming to align with international climate goals and demonstrates a clear commitment to reducing environmental impact across all major emission sources.

15.1 NET ZERO ROADMAP SCOPE 1 & 2

This report demonstrates that A Airport has the capacity to fulfil both requirements of achieving zero carbon emissions under the direct control of airport operators (Scope 1 and 2) by 2050, in line with the directives set forth by ACI EUROPE, and aligning with the IPCC Special Report's 1.5 degrees Celsius trajectory by adhering to the various recommendations outlined herein. Specifically, by 2030, it will achieve a comprehensive 50% reduction in CO₂ emissions compared to 2011, ultimately attaining a Net Zero status by 2040.

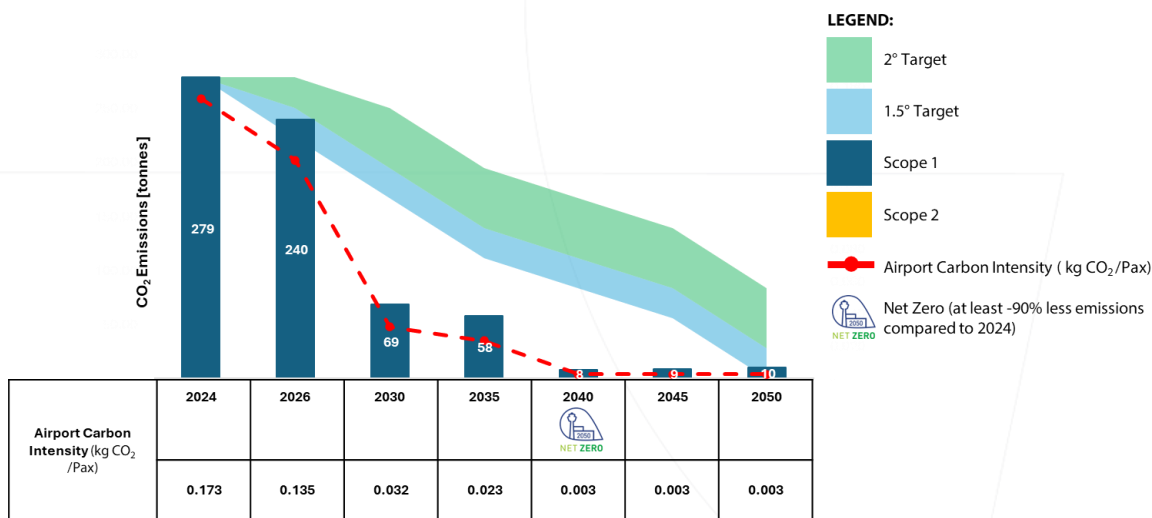


Figure 21: Net Zero Roadmap - Scope 1&2 Emissions

The final net zero road map, represented as Pathway 2 in this graph, outlines a clear trajectory toward achieving a 97% reduction in emissions by 2050 compared to 2024 levels. The pathway demonstrates a steep decline in total CO₂ emissions, dropping from 279 tons in 2024 to just 10 tons by 2050. This ambitious reduction aligns with international climate targets, with the shaded areas in the graph indicating the 2°C and 1.5°C global warming limits. The road map also highlights interim milestones, such as reducing emissions to 69 tons by 2030 and further to 8 tons in 2040, emphasizing a sustained and aggressive approach to decarbonization.

Throughout this journey, the graph tracks both Scope 1 and Scope 2 emissions, reflecting direct and indirect sources, respectively. The red dashed line illustrates the reduction in airport carbon intensity (measured in kg CO₂ per passenger), which steadily declines in parallel with total emissions. The pathway's progression is marked by the achievement of net zero, defined here as at least a 90% decrease in emissions from the 2024 baseline. This road map underscores the necessity of continuous improvement and innovation in operational practices, energy sourcing, and efficiency measures to meet stringent climate goals while maintaining essential airport functions.

16 RISK ANALYSIS

Analysing the risks associated with a Net Zero Roadmap is crucial for effective planning and implementation. Achieving a net-zero carbon footprint involves significant changes in energy systems, industries, and societal behaviour. There are several factors that should be considered, below a framework about it:

Regulatory and Policy risk:

Changes in government policies and regulations can impact the feasibility and cost-effectiveness of the roadmap. Even political instability and shifts in leadership may lead to policy reversals or delays in implementation.

Technological risk:

Dependence on emerging and unproven technologies can pose risks, including delays in development or unexpected technical challenges. The AHO Airport roadmap prioritizes a realistic approach, aiming to align objectives with practical feasibility.

Economic risk:

The costs associated with transitioning to net zero may be higher than anticipated, potentially straining budgets and financial resources. Also, economic downturns or fluctuations in energy prices can impact the financial viability of projects.

Infrastructure and Implementation risk:

The need for new infrastructure (e.g., renewable energy plants, electric vehicle charging stations) introduces risks related to construction delays, cost overruns, and technical issues. Also, Delays in project implementation can result from factors such as permitting issues, community opposition, or unforeseen technical challenges.

Supply Chain risk:

Reliance on specific suppliers for critical poses supply chain vulnerabilities and geopolitical factors affecting the availability of materials can disrupt the supply chain.

Stakeholder involvement risk:

Possibility of encountering resistance, lack of support, or conflicting interests from stakeholders, which could impede progress or lead to the Net Zero roadmap failure.

Measurement and Reporting risk:

Accurate measurement and reporting of carbon emissions reductions may be challenging, leading to potential inaccuracies in assessing progress and lack of standardized reporting frameworks may result in inconsistent data.

A comprehensive risk management plan should address these factors, incorporating contingency plans, monitoring mechanisms, and regular reviews to adapt to evolving conditions. Additionally, engaging stakeholders, fostering innovation, and building flexibility into the roadmap can enhance resilience to these risks.