Report 2025/01 | For Satu Mare Intercommunity Development Association

VISTA ANALYSE

# Renewable energy solutions for Satu Mare International Airport

## Pre-feasibility study

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# Document details

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| Title | Renewable energy solutions for Satu Mare International Airport – pre-feasibility study |
| Report Number | 2025/01 |
| Author | Haakon Vennemo, Sarah Eidsmo, Leif Grandum, Magnus Digre Nord, Herman Ringdal |
| ISBN | 978-82-8126-712-1 |
| Project Number | 24-HVE-04 |
| Project Leader | Haakon Vennemo |
| Commissioned by | Satu Mare County Intercommunity Development Association |
| Date of completion | January 10th, 2025 |
| Source front page photo | Vecteezy and Chelseadeeyo on Unsplash |
| Availability | Public |
| Keywords | Empirical analysis, electricity and energy, transport |

# About us

Vista Analyse is a social science consultancy whose emphasis is economic research, policy analysis and advice, and evaluations. We carry out projects to the highest professional standards, with independence and integrity. Our key thematic areas include climate change, energy, transport, urban planning and welfare issues.

Our employees have high academic credentials and broad experience in consulting. When needed, we utilise an extensive network of companies and resource persons both nationally and internationally. The company is fully employee owned.

# Preface

The pre-feasibility study on renewable energy solutions for Satu Mare International Airport is carried out by Vista Analyse in the period July 2024 – January 2025. It is an output from a collaboration project by the same name between Vista Analyse and The Satu Mare Intercommunity Development Association.

Financial support is provided by the EEA Grants. The EEA grants represent the contribution of the states of Iceland, Liechtenstein and Norway to a greener, more competitive and more inclusive Europe. There are two major objectives: reducing economic and social disparities in Europe and strengthening bilateral relations between donor states and the 15 EU states in Central and Eastern Europe and the Balkans. The 3 donor states cooperate closely with the EU within the framework of the Agreement on the European Economic Area. Donor states provided 3.3 billion Euros through grant schemes between 1994 and 2014. For the period 2014-2021, EEA Grants have a value of 1.55 billion Euros. More information on EEA Grants: www.eeagrants.ro. Innovation Norway manages the EEA Grants in Romania.

We would like to thank the Satu Mare Intercommunity Development Association and its Managing Director Nicoleta Lasan for support and encouragement in the pre-feasibility study. Further we would like to thank the administration at Satu Mare International Airport and its Managing Director Mihai Pătraşcu for support and encouragement. Finally, our thanks go out to representatives of suppliers of solar energy and battery solutions in Satu Mare, and representatives of local authorities, who have patiently answered questions and provided detailed information of great value for the study.

January 10th, 2025

Haakon Vennemo
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# Contents

# Executive summary

*Satu Mare International Airport is considering renewable energy solutions for its renovation and expansion. Considering the resource potential, as well as the economic and regulatory environment, this study considers solar energy to be the most promising energy solution. We analyse the business case for a 400 kWp solar electricity system in combination with batteries of different capacities. At current electricity prices a system without batteries gives the best net present value. At 40-100% higher electricity prices or 35-65% lower battery prices systems with batteries are equally or more profitable in terms of net present value.*

## Solar electricity is the best renewable energy solution for Satu Mare Airport

Satu Mare International Airport opened in 1936 and is an important regional airport in North-West Romania. The airport is currently undergoing renovation and extension. A new terminal building is added, and the old terminal building is remodeled with up-to-date energy solutions and other improvements.

The airport is interested in using renewable energy to cover its electricity demand. In a recent scoping study Vista Analyse (2023) found that solar energy has the best potential in Satu Mare. In this pre-feasibility study, we confirm the conclusion. Wind electricity is not a good alternative both because of wind conditions and because it is problematic to operate wind turbines close to the airport. There is no known source of geothermal heat that is suitable for power generation at the airport and no resources for hydropower.

This leaves solar energy, in terms of solar heating and solar electricity (photovoltaic (PV) panels). The airport already has solar heating installed on the roof and a water-based distribution of heat around the building. Hence, the study focuses on solar electricity, PV panels, in combination with batteries of different capacities.

## The regulatory environment is positive, and the resource potential is good

In Romania, the regulations and laws regarding renewable energy production differ depending on whether you are a prosumer or not, and the production capacity of the installation. Satu Mare Airport qualifies as a prosumer.

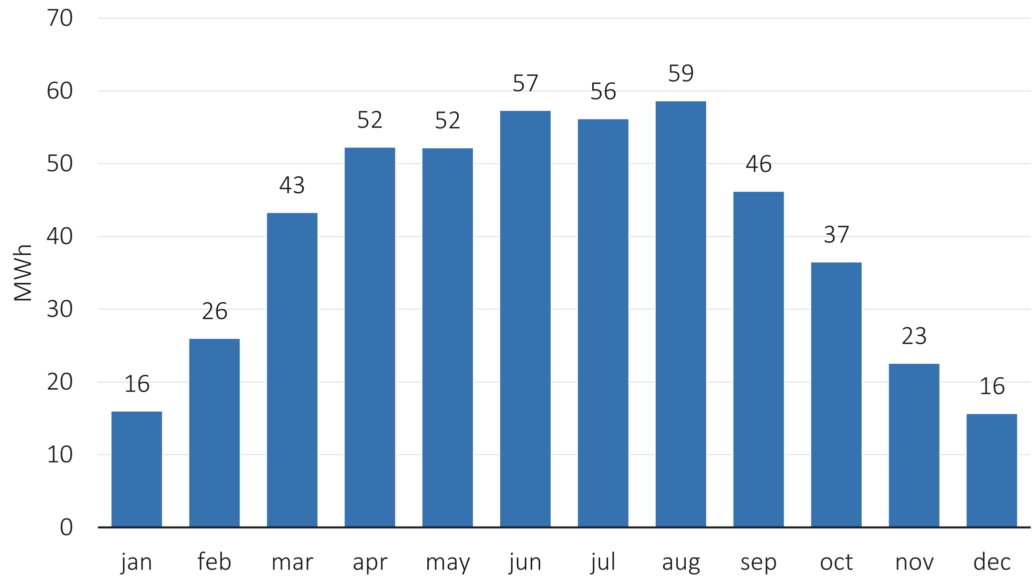
Prosumers that have an installation with a maximum effect of 400 kilowatts are treated according to procedures given in ANRE Order nr. 19/2022. This order states that prosumers who own a renewable energy installation with a maximum effect of 400 kilowatts can commercialise the electricity produced without the need for registration and authorisation of their operation. For prosumers with a maximum capacity between 200 and 400 kilowatts, the *financial regulation mechanism* applies. Electricity suppliers that enter contract with these prosumers are obligated to buy the electricity that is produced and delivered to the grid.

The resource potential for solar electricity production is limited by the available area and the solar efficiency of that area.

The airport has an area of approximately 52 000 square meters at ground level available for installing solar PV panels. That is more than sufficient for installing a 400 kWp system. The ground level area is flat with pastures and well suited for hosting PV panels. The surrounding area is also flat and there are no major obstacles that could block the sun.

To assess the solar irradiation at the airport, we use the simulation software PVGIS tool from the European Commission. PVGIS uses satellite data to simulate solar radiation at a given coordinate. The monthly average power generation from a 400 kWp system at the Satu Mare Airport is shown in Figure S.1 below.

**Figure S.1 Monthly average power generation with 400 kWp system at Satu Mare Airport. Estimate.**




*Source: PVGIS*

Delivered power from the PV panels will be lower than the power produced by the PV cells due to loss in cables, inverters and dust or snow covering the modules. The modules will also lose efficiency over time. We assume a total system loss of 14%, which is the standard assumption by PVGIS.

## A solar electricity installation has high net present value

According to key suppliers in Satu Mare solar panels can be provided for an investment cost of 650-1000 euros per kWp, VAT excluded. This includes all the labor needed to install the modules, the necessary documentation, the structure the panels are mounted on, photovoltaic cables (DC), power cables (AC), the panels (AC and DC), inverters, measuring and monitoring equipment (LOGGER), perimeter fencing, and warranties. The panels are expected to produce upwards of 99 % initial capacity in the first year, before efficiency decreases 0.4% each year throughout their

30-year lifespan. During this period production should stay above 85% of initial capacity with annual maintenance.

The revenue associated with installing photovoltaic panels comes from a combination of reduced electricity costs on the one hand and income from selling surplus electricity to the grid on the other. As of January 2025, the Romanian government has enforced caps on electricity prices to help manage the rising energy costs. According to Article 1 in Emergency Ordinance No. 192/2022, which has been extended to March 31$^{st}$, 2025, the price for non-household consumers is 0.26 euros per kWh including VAT.

In the hours the panels produce more than the airport consumes, the airport can sell this electricity to the grid at a current price of 0.26 euros per kWh. In normal circumstances, the price received for selling electricity to the grid is calculated as the weighted average day-ahead market price for the month in which the electricity was generated. However, the grid operator in Satu Mare informs that at this point there will be at constant price of 0.06 euros per kWh.

Based on these assumptions, and using a real discount rate of 10% we calculate the net present value of a 400 kWp solar PV installation to be about 465 000 – 630 000 euros. Hence, the PV installation is clearly profitable. Prices exclusive of VAT is used in the calculation as it is assumed that the airport can reclaim VAT paid.

Besides the financial net present value, the installation will contribute to lower $CO_2$-emissions and lower emissions of $NO_x$ and particulate matter. Emissions of particulate matter, in particular the small particles ($PM_{2.5}$) is a serious health problem in Romania and Europe.

## At current prices, batteries are not profitable

Adding batteries to the solar PV installation will allow the airport to store surplus electricity instead of selling it to the grid. Later, it can use the stored electricity instead of purchasing from the grid. This generates an annual profit If the price of purchased electricity is higher than the price of sold electricity. To determine the net present value of batteries the annual profit must be compared to the investment cost.

A battery of 193.5 kW is available in Satu Mare at an investment cost of 66 000 - 90 000 euros excl VAT, everything included. Annual operational costs are given as 330 - 2 000 euro.

Combining the information, we find that installing one battery returns a net present value of minus 30 000 – minus 70 000. Installing a battery with the installation is therefore not profitable at current prices. To put it differently a battery reduces the positive net present value of the solar PV installation. A second battery will be even less profitable than the first, because there may be sufficient solar power to fill the first battery, but not the second. Therefore, capacity utilization of the second battery will be lower.

## Batteries are profitable at a higher price differential and/or a lower battery cost

As noted, the annual profit from a battery depends on the price differential between the price of electricity purchased and the price of electricity sold. We estimate that if the price of purchased electricity increases 40-100%, an investment in the first battery is profitable, other things equal.

A rise in the price differential increases the annual profit of a battery. An alternative way to turn an overall profit is to lower the cost. If the cost of a battery decreases 35-65%, the investment in a battery is profitable, other things equal.

## The next step is to detail the project

Since this pre-feasibility study indicates that a 400 kWp PV installation at Satu Mare Airport is robustly profitable, the next step would be to detail the project. When detailing the project, a preliminary step is to compare the estimated incomes and costs in this report to data from a nearby, existing PV installation, of which there is at least one. Given that the project is profitable considering additional information, the next step would be to detail the project according to the requirements of relevant financial institutions and relevant authorities.

As a further step the current 400 kWp capacity might be reconsidered. Since a 400 kWp capacity unit is robustly profitable a somewhat larger installation probably is profitable as well. The regulatory process is more complicated, for instance with respect connection to the electricity grid, but it might be worthwhile conducting the necessary analysis. Additional electricity production could for instance be used to modernize the administrative building of the airport, which so far is excluded from the project.

# 1 Background and scope

Our aim with this report is to examine the potential for production of renewable energy at Satu Mare International Airport in Romania. Along with assessing resource potential, regulatory framework and economic aspects, this comes with mapping the current and future energy consumption and reviewing the alternative energy sources. The report is meant to produce realistic estimates on the financing and profitability of renewable energy production at the airport.

This chapter sets the stage by contextualizing the airport as an investment project, discussing transport infrastructure in Romania and the political aspects of energy consumption. Chapter 2 presents the predicted airport activity and discusses current and future energy consumption. Chapter 3 illuminates the conditions and constraints regarding renewable energy production at the airport, in both a physical and regulatory sense, with their associated economic aspects.

Based on chapter 1-3 we develop a business case in chapter 4 with three scenarios for renewable energy production at Satu Mare International Airport.

## 1.1 Transport in Satu Mare

The county of Satu Mare is located in the North-West Development Region of Romania. The county has 330,000 inhabitants, of which 90,000 live in the county capital, Satu Mare. Its area stretches across 4418 $km^2$, which makes up roughly 2% of Romania's entire land area.

Satu Mare borders the counties of Bihor, Salaj and Maramure from south to east, and the countries of Ukraine and Hungary to the north and west. This makes the county subject to issues of international as well as regional transport. As the constraints of the covid-pandemic are thoroughly lifted, the pressure is back on transport and transport infrastructure as prerequisites for economic growth.

In recent years regional transport infrastructure has been an area of active investment in Satu Mare, especially with regard to the road network. Infrastructural investments are still necessary to increase traffic safety and efficiency, and ensure sufficient emergency service deliverance, in the county and in Romania as a whole (Satu Mare County, 2022). The General Transport Master Plan of Romania stated in 2015 that motorways and the national road network made up only 20% of the entire network (Aecom, 2015). Additionally, about 50% of the conditions on national roads were categorized as either average or poor. For this and other reasons, there are several ongoing and planned rehabilitation- and expansion projects regarding the road network in Satu Mare and Romania, which point out the existence of challenges related to transport infrastructure.

An insufficient road network also emphasizes the importance of other means of transportation, e.g. air transport. By quickly and safely accommodating the mobility needs of people and businesses, air transport substitutes for long time-consuming domestic and international routes by road or railway, while simultaneously contributing to the economy. As an industry, air transport contributed 4.2 billion dollars, about 1.67%, to the Romanian GDP in 2019 (Air Transport Action Group, 2020). To ensure that air transport supports and stimulates economic growth, transport infrastructure proves vital. For the county of Satu Mare this means that the international airport must maintain modern standards in terms of safety, efficiency and technology. As the connection to motorways and national road networks is poor, the airport plays a pivotal role in shortening travel time, increasing mobility, enabling business opportunities and facilitating tourism.

Considering this, Satu Mare International Airport has been subject to several investment projects over the last ten years. Due to recent economic and social progress in Romania's North-West Development Region, the airport's significance is growing, and the demand for air transport is increasing (Satu Mare International Airport, 2023). Its location contributes to connecting the northwestern region to the rest of the country and the continent, with regular flights to Bucharest and London, and seasonal flights to Antalya. Despite this and recent years' efforts to increase the number of destinations and departures, airlines have been drawn to other state funded competing airports. Potentially, this will change shortly, as EU funds and the Satu Mare county council have enabled the construction of a new and modern terminal building. The new terminal will not only increase capacity and traveller- and flight efficiency. It will also improve energy efficiency and possibly produce energy of its own. Energy efficiency, energy production and energy consumption of the airport is the focus of this report.

## 1.2 Satu Mare International Airport

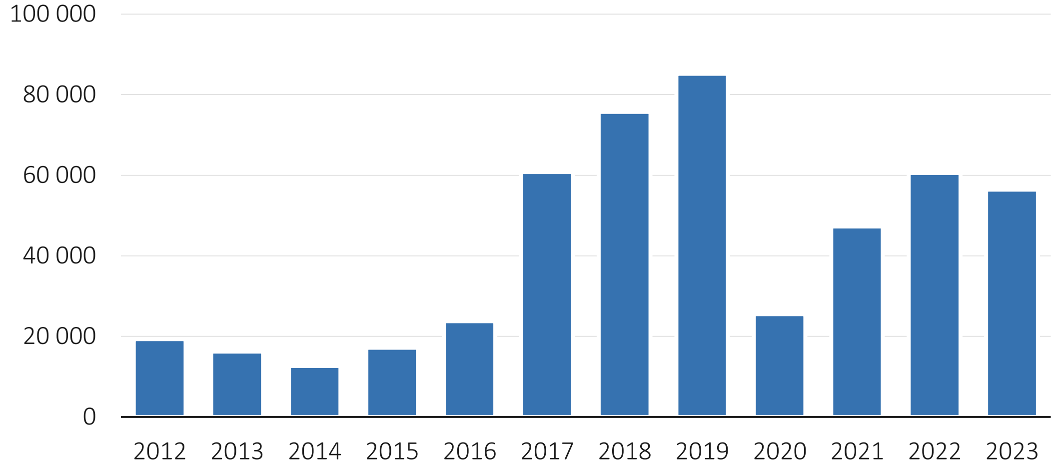
Satu Mare International Airport is located 14 km south of the Satu Mare city centre. It was opened in 1936 and was inaugurated with its current runway in 1975. It is one of the oldest accredited airports in Romania and plays an important role in transport infrastructure and business in the county. It is autonomously run as a legal organization with its own board and business administration, but the county council is the owner of the airport.

### 1.2.1 Investments and modernization

In recent years the airport has been the object of several investment projects. The first one, "*Rehabilitation and modernization of movement surfaces and expansion of terminal at Satu Mare Airport*", commenced in 2015. Upon the project's completion, passenger traffic responded immediately, increasing 155% from 2016 to 2017 (Satu Mare County, 2022). This growth continued and peaked in 2019 at 85 171 passengers and 2 390 flight movements.

The airport activity in Satu Mare was deeply affected by the ensuing pandemic and its restrictions on travel, reducing the number of passengers by 70% in 2020 (Satu Mare International Airport, 2023). As the restrictions are now long gone, air traffic has again accelerated, and the airport experiences better capacity utilization.

Figure 1.1 Total number of passengers on commercial flights




*Source: Satu Mare International Airport*

In 2022 the county council of Satu Mare signed a contract with the Romanian Ministry of Transport, securing 431.9 million RON for a new modernization project at the airport (Banila, 2022). The project was financed mainly through the EU's Structural Funds, supplemented by contributions from the state budget and the budget of the county. In addition to a new terminal building, the new modernization project includes the following (Bog'Art, 2024):

- security enhancements
- installation of automated baggage handling system
- upgraded runway lighting system
- construction of a new fire station
- expansion of the aircraft parking apron
- refurbishment of the existing terminal

When assessing the current conditions of the airport, the 2023 business plan states that the most important areas of improvement were related to the capacity of terminal passenger processing and the level of operation compared to existing traffic demand (Satu Mare International Airport, 2023). Additionally, the runway was severely deteriorated, further stressing the need for improved airport infrastructure and the importance of the funds acquired the preceding year.

In June 2024, contractor Bog'Art informed that the construction work was 95% completed, though the project originally was expected to be completed by the end of 2023. All investment costs through 2023 would be covered by the EU funds, while costs incurred after 2023 needed to be financed by the Satu Mare county council. This has delayed the final stage of the project, but the county council has successfully secured the necessary credit to finalize it.

### 1.2.2 A need for more energy

Once completed, the airport will have five main elements that all require a sufficient and reliable power supply: two terminals, one administrative office building, one building serving as a fire station, and the beacons of the runway. With one new and one refurbished terminal, there will be several improvements with regards to energy efficiency. Nevertheless, technical airport equipment and large public buildings in general will consume significant amounts of power.

The office building and the old fire station have been heated through fuel combustion and have therefore not been the most electricity demanding features. However, there has still been a need for a certain amount of electrical energy to power lights, computers, communication systems, vehicles and other chargeable equipment.

The two terminal buildings and the new fire station will use ground-to-air heat pumps. and instalments of solar thermal energy on the roofs. This is a lot more energy efficient than burning fuel, but the terminals require energy for more than just heating. After all they are the buildings that accommodate all passengers, which makes them the predominant electricity consuming feature of airports in general (Li, 2017).

Capacity drastically increases with the new terminal, and the number of passengers is expected to increase by over 12% in 2025 (Satu Mare International Airport, 2023). This means energy consumption most likely will rise as well, along with operational costs (Li, 2017). As for the heating of the administrative building, fuel combustion is polluting and maintenance-requiring and could advantageously be replaced as an energy source. Evidently, there is a need for more, and preferably cheap, power.

## 1.3 Political context

Airports are key elements of transport infrastructure, ensuring mobility of people and goods both nationally and internationally. Combined with their economies of scale, massive energy consumption and the vast $CO_2$ emissions from aviation, there is also a political context to airports and their energy conditions. Satu Mare International Airport is no exception.

### 1.3.1 The European Union

As a member of the EU, Romania is bound by the EU's goals and targets for GHG emission reduction, which implies more renewable energy. Through the policy initiative package European Green Deal, the Union's ultimate goal is reaching climate neutrality for the entire continent by 2050. Among other things, this entails reducing GHG emissions by 55% compared to 1990 within 2030, and for the share of renewables in the EU's overall energy consumption to be 42.5% by the same year (EU, 2023). In combination with the energy market disruption caused by Russia's invasion of Ukraine, these goals have motivated the 2022 launch of the REPowerEU Plan, which is helping save energy, diversify energy supply and produce clean energy.

While the green transition is communal and cooperative in essence, the EU also runs specific programs of cohesion and interconnectivity. The Cohesion Policy aims at supporting competitiveness, economic growth and sustainable development, targeting regions and cities in the union. It is delivered through specific funds, such as the European Regional Development Fund (ERDF) and the Cohesion Fund (CF). These are among the EUs structural funds, where the latter particularly supports projects in the fields of environment and transport in less developed regions.

These strategies contextualize the Satu Mare International Airport on a European political level. The airport's significance for economic development and regional transport infrastructure makes it a relevant investment project for EU Structural Funds. The airport's capacity expansion, while exploiting modern and energy efficient solutions, brings an increased need for energy. Given the EU's goals and policy programs regarding green transitioning, the energy should preferably be met by energy from renewable sources.

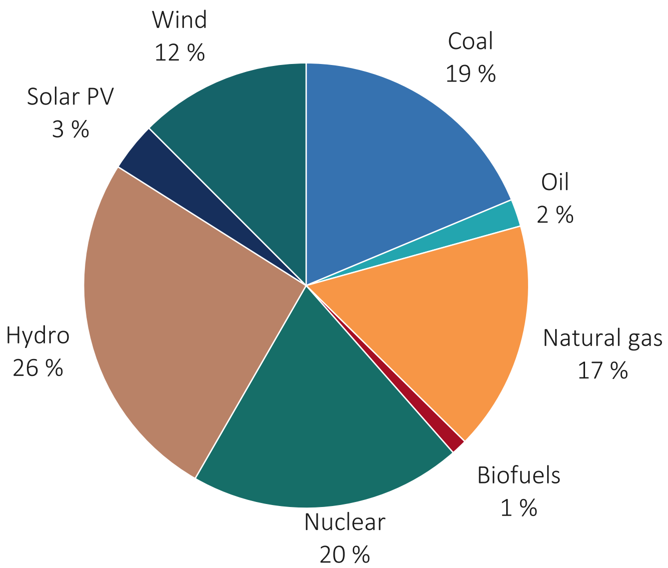
### 1.3.2 Renewable energy in Romania and Satu Mare

EU policies and directives are complemented by domestic, Romanian policies. Romania's National Energy Climate Plan (Romanian Ministry of Environment, Water and Forests, 2020) has set a goal of 49% renewable energy in electricity production in 2030, an increase of 6 percentage points compared to today. The goal for the share of renewable energy in energy production is 30.7%. This figure is pulled down by lower shares in transportation (14.2% renewables) and heating and cooling (33%).

To reach these goals, and as a part of the Romanian National Resiliency and Recovery Plan, coal and lignite will be phased out from electricity generation by 2032. This entails replacing about 20% of total generation and is a huge opportunity for renewable energy technologies. Factoring in some increase in total consumption, the goal is to develop 6.9 GW renewable power by 2030, compared to 2015.

As illustrated by Figure 1.2, renewable energy makes up 41% of the electricity generation sources in Romania. Another 21% comes from nuclear power and biofuels, which are not renewable, but are associated with low emissions. The remaining 37% are coal, oil and natural gas, meaning about two fifths of Romania's electricity is generated from non-renewable sources with considerable GHG emissions.

Figure 1.2 Electricity generation sources, Romania, 2022




*Source: IEA Data Services, 2024*

In the county of Satu Mare there is high potential for contributing to the goals of the National Energy Climate Plan. In some rural areas biomass is used for heating, and there are some scattered occurrences of wind- and hydropower (Asociata de Dezvoltare Judetul Satu Mare, 2023). However, the most common renewable energy source is solar power, which also has the best resource potential (Vista Analyse, 2023). Solar photovoltaic (PV) panels are found on the roofs of numerous houses and public buildings, and there are several providers of solar PVs in the county.

## 1.4 Potential renewable energy sources and energy efficiency measures

Vista Analyse has analysed the potential for renewable energy sources in the Satu Mare region (Vista Analyse, 2023). The report evaluated the potential for energy production from several renewable sources, including solar, wind, bioenergy, hydropower, and geothermal energy. Solar energy and bioenergy were deemed the most promising sources in Satu Mare.

The resource potential for wind energy, as measured by average wind speed, is not particularly good. It is also problematic to implement wind turbines at the airport. There is no known source of geothermal heat that is suitable for power generation at the airport and no resources for hydropower.

There are biomass resources in the region, but utilizing these for power generation at the airport is likely expensive due to lack of economy of scale and uncertainty regarding stable delivery of substrate. The new terminal will use electricity as the main source for heating.

Solar energy has the best potential for energy production at the airport, both through solar heating and photovoltaic cells. Both technologies are well-known and can be implemented at any scale. The airport already has solar heating panels installed on the roof and a water-based distribution of heat around the building. Power that is necessary for running the heat pumps and other equipment, is supplied by the grid.

The airport terminal is newly renovated with modern energy efficient solutions such as solar heating and ground-to-water heat pumps. Thus, this report does not look at energy efficiency measures, but rather options for complementing the grid with solar PV panels and possibly batteries, to supply the airport with the necessary power to operate.

# 2 Airport activity and energy consumption

To assess the feasibility of solar energy production at Satu Mare International Airport, a comprehensive understanding of the airport and its energy consumption is required. In this chapter we present numbers of this consumption the recent years. We decompose them to estimate the future need for energy, taking into account both the increase in expected number of passengers and the efficiency gains from refurbishment and a new modern terminal.

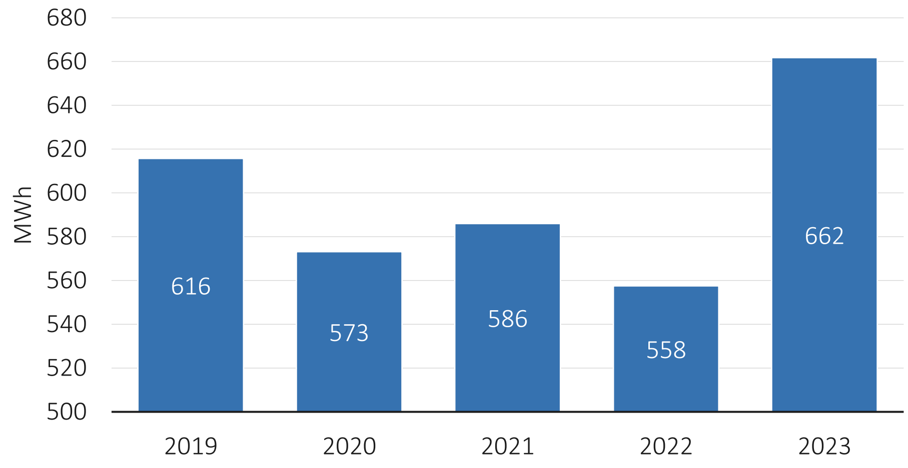
## 2.1 Energy consumption at Satu Mare International Airport

In general, airports cover wide areas and consume vast amounts of energy compared to other transportation hubs (Li, 2017). There are several aspects of an airport that create rather extensive requirements for electrical energy:

- Operation of the terminal: lighting and heating, ventilation and air-conditioning (HVAC) may require a lot of energy, particularly at bigger airports.
- Handling of luggage: conveyer belts and other automated luggage systems require energy for transporting and sorting luggage.
- Security: surveillance systems and x-ray scanners need sufficient energy.
- IT and communication: Data systems, servers, information boards, radars and communication systems all depend on energy to operate.

Exactly how much energy these functions and installations consume is largely determined by the scale of the airport and how much it is used. For most components this mainly depends on the number of travellers and flights, while tasks like lighting and HVAC have a more baseline-oriented usage.

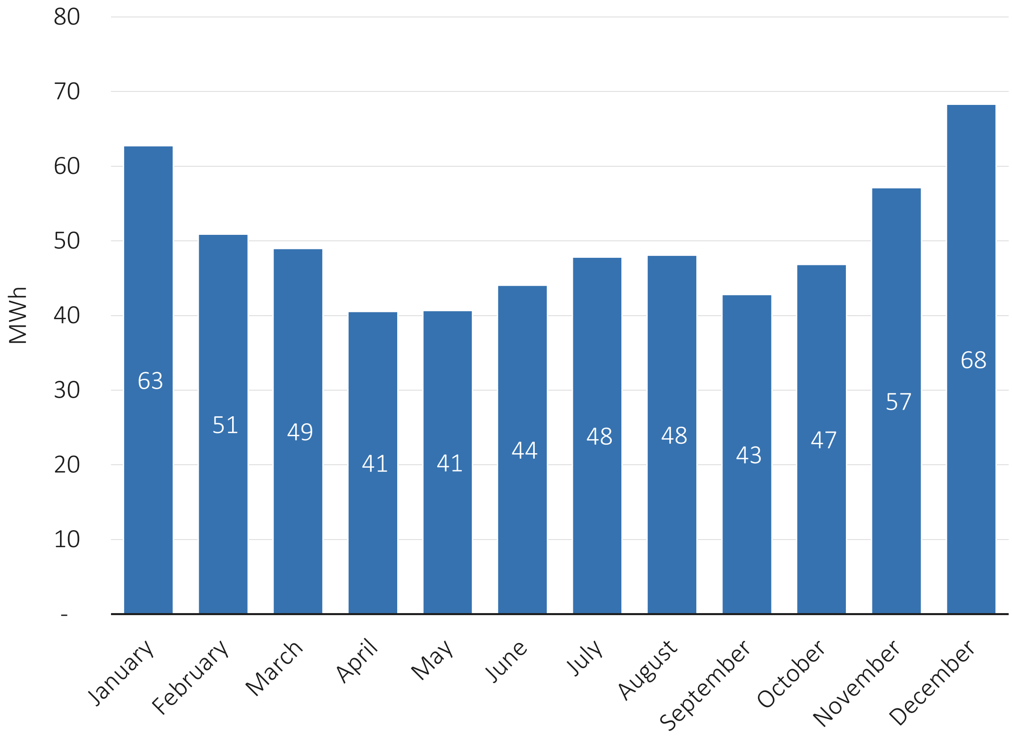
Figure 2.1 Electricity consumption at Satu Mare International Airport 2019-2023




*Source: Satu Mare International Airport Management*

Figure 2.1 shows the electricity consumption at Satu Mare International Airport the last five years. During the pandemic, consumption declined by 58 MWh from 2019 to 2022, before jumping to a total of 662 MWh in 2023, when construction of the new terminal commenced. The investment project at the airport results in a considerably larger total terminal area, implying a larger future electricity consumption. After refurbishment, the existing terminal will be comprised of four floors, with a total usable area of 3 130 $m^2$. In addition to a basement for different technical rooms, luggage lane monitoring, etc., the new terminal will have two floors, giving a total of 5778 $m^2$. The two terminals combined then hold 8 908 $m^2$ of usable area, that will require energy for different purposes. Still, the terminals are quite small for an international airport. For comparison the terminal building at Oslo Airport Gardermoen has an area of 295 000 $m^2$.

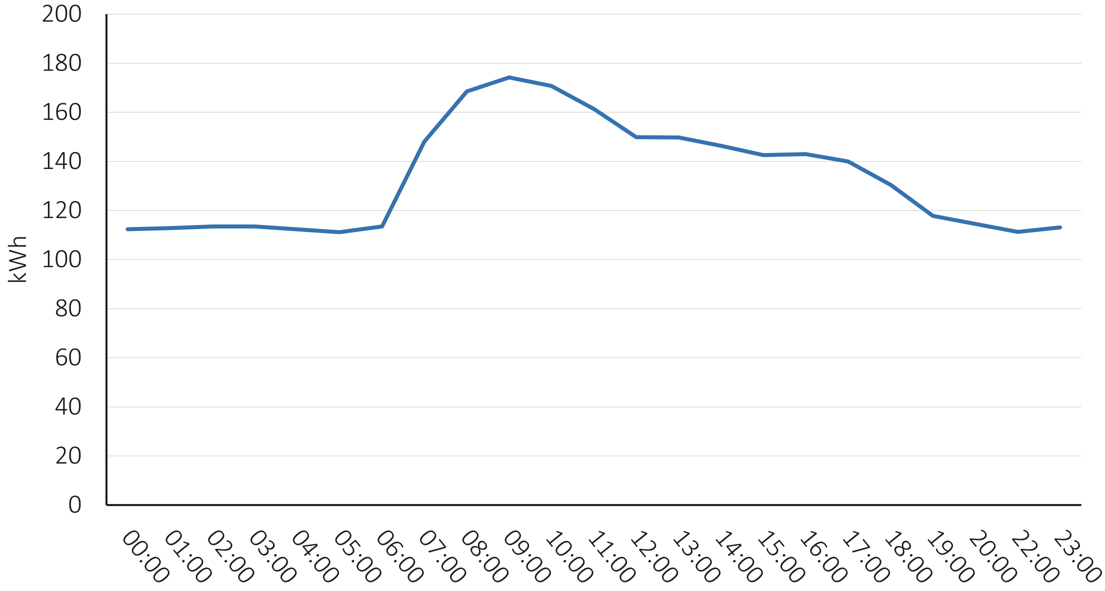
Figure 2.2 Average monthly electricity consumption, 2019-2023




*Source: Satu Mare International Airport Management and Vista Analyse*

For an airport, the average monthly electricity consumption profile takes on a somewhat expected shape. As shown in Figure 2.2, consumption is highest during winter months, when temperatures are low, requiring more electricity for indoor heating. As spring arrives and outside temperatures rise, consumption declines and is at its lowest during April and May with 41 MWh. In summertime consumption increases again, most likely due to increased traffic, as well as the need for indoor cooling. Consumption then sees a little dip in the early autumn, before increasing as winter approaches again. It peaks in December at 68 MWh.

Figure 2.3 Average hourly electricity consumption, November and December 2023




*Source: Satu Mare International Airport Management and Vista Analyse*

Average hourly electricity consumption is shown in Figure 2.3, and is based on the last two months of 2023. The consumption is lowest during the night, with close to no variation between the hourly averages. The consumption stays stable around 112 kWh from midnight to around 06:00. From there, it quickly increases over the next three hours, peaking at about 175 kWh at 09:00. The consumption then gradually declines throughout the day, staying above 140 kWh per hour until 16.30, before swiftly coming down to about 112 kWh again during the evening. This consumption profile appears fairly typical for a public building. However, the kilowatt-hours themselves may be a little overblown due to the construction work these two months.

## 2.2 Expected activity and electricity consumption at the airport

As previously mentioned, accommodating passengers is the main purpose of the terminal buildings at airports, which is also what causes them to consume a lot of energy. The relationship between energy consumption and number of passengers at Satu Mare International Airport specifically is therefore essential in estimating the future need for energy.

### 2.2.1 Passengers and flights

As two new airlines intend to start operating regularly from Satu Mare, the airport management expects an increase in airport activity in the coming years (Satu Mare International Airport, 2023). Based on post-pandemic traffic trends at airports, management has estimated the expected number of passengers and flight movements each year up until 2035. This is summarized in Table 2.1.

Table 2.1 Expected number of passengers and flight movements

| Year | Number of passengers | Number of flight movements |
|---|---:|---:|
| 2024 | 65 230 | 1 300 |
| 2025 | 73 058 | 1 456 |
| 2026 | 81 825 | 1 631 |
| 2027 | 91 644 | 1 827 |
| 2028 | 109 973 | 2 192 |
| 2029 | 126 469 | 2 521 |
| 2030 | 145 439 | 2 899 |
| 2031 | 167 255 | 3 334 |
| 2032 | 192 343 | 3 834 |
| 2033 | 221 194 | 4 409 |
| 2034 | 254 373 | 5 070 |
| 2035 | 292 529 | 5 831 |

*Source: Satu Mare International Airport*

These projections mean increasing the number of passengers from 2023 more than five-fold over the next twelve years. They entail a gradual, but substantial change in traffic from previous years and the current situation, which is likely to have consequences for energy consumption (Li, 2017).

### 2.2.2 Estimated electricity consumption

The estimates for future energy consumption at the airport terminals are based on data provided by the Satu Mare International airport management. This data includes:

- Number of passengers per year, from 2019 to 2023.
- Estimated number of passengers per year, from 2025 to 2035.
- Monthly electricity consumption (in kWh), from January 2019 to December 2023.
- The floor area (in square meters) of the old and new terminal buildings.

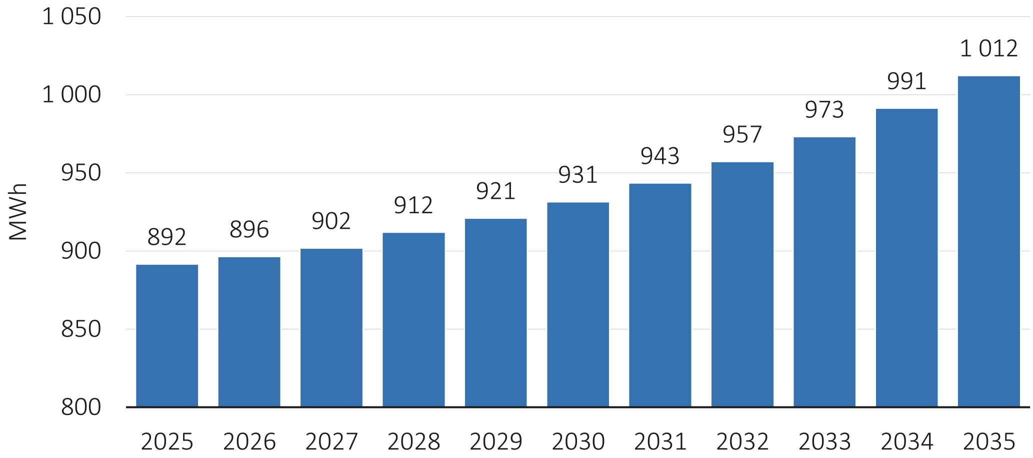
We (European Comission, 2024), incorporating a dummy variable for each month based on historical data and one variable for monthly passenger count. This gave us an estimate for *annual* electricity consumption based on the area of the old terminal.

In order to adjust this estimate for the refurbishment of the old terminal and the opening of the new terminal, we assume that the refurbished terminal and the new terminal will be more energy efficient than the old terminal. Additionally, we assume that the increase in indoor area will not lead to a proportional rise in electricity consumption. While the old terminal was smaller, it still contained all the essential equipment required for airport operations. We do not anticipate a proportional increase in electricity-consuming equipment with the additional indoor area. As a result, the electricity consumption per square meter is expected to be lower in the refurbished terminal and the new terminal building. Taking this into account, we have assumed that the new terminal will be 50% more energy efficient than the old.

The annual electricity consumption is then split between *months* based on the historical distribution of consumption from 2019 to 2023. As a result, electricity consumption is higher in winter months. Similarly, the expected annual number of passengers is distributed across months according to historical passenger data from 2019 to 2023, allowing us to account for the rise in passenger numbers during vacation periods, especially in the summer months. Electricity consumption per *hour* is based on data giving the variation between hours from November 1st, 2023, to January 1st, 2024.

Figure 2.4 shows the estimated annual electricity consumption at Satu Mare Airport. The 2025 estimate is 300 MWh higher than the average in the historical data, accounting for the new equipment and additional terminal building. The yearly consumption increases every year as the number of passengers increase. The complete table with monthly estimates is attached in appendix A.

Figure 2.4 Estimated yearly electricity consumption at Satu Mare International Airport




*Source: Vista Analyse*

# 3 Key pre-conditions for solar energy production

## 3.1 Regulations

In Romania, the regulations and laws regarding renewable energy production differ depending on whether you are a prosumer or not, as well as the production capacity of the installation.

A prosumer is an individual, household or business that both produces and consumes a good or service. In the context of energy, it often refers to households or businesses that both generate electricity using renewable energy sources, such as solar panels, and at the same time use this energy to cover their own demand.

According to Article 3, point 95 of Law No. 123/2012 (Ministerul Justitiei, 2012), a prosumer is defined a final consumer that also meets the following criteria:

- conducts its activities in its own space related to a connection point with the electrical network,
- produces electricity from renewable energy sources for their own use,
- the main activity is not electricity production,
- consumes, stores, or sells the produced electricity from renewable energy sources to either the electricity supplier the prosumer has a contract with, or other consumers.

By this definition, Satu Mare International airport qualifies as a prosumer.

Prosumers that have an installation with a maximum effect of 400 kilowatts are treated according to procedures given in ANRE Order nr. 19/2022 (Ministerul Justitiei, 2022). This order states that prosumers who own a renewable energy installation with a maximum effect of 400 kilowatts can commercialise the electricity produced without the need for registration and authorisation of their operation.

The setup for connecting the renewable energy installation to the grid must allow both consumption from the grid and delivery of the produced electricity to the grid in the same connection. Measuring the electricity must be done with either a smart meter or a meter that allows remote reading and can be integrated with the smart meters used by the grid operator. If the prosumer has a system that includes energy storage, a separate meter must be installed for that system.

The order also establishes two different mechanisms based on the prosumer's installed capacity:

1. For prosumers with a maximum capacity of less than 200 kilowatts, the quantitative mechanism applies. Under this mechanism, the prosumer is billed for the difference between the electricity consumed from the grid and the electricity they produce.
2. For prosumers with a maximum capacity between 200 and 400 kilowatts, the financial regulation mechanism applies. Electricity suppliers that enter contract with these prosumers are obligated to buy the electricity that is produced and delivered to the grid at the weighted

average price registered in the day-ahead market for the month the electricity was produced and delivered.

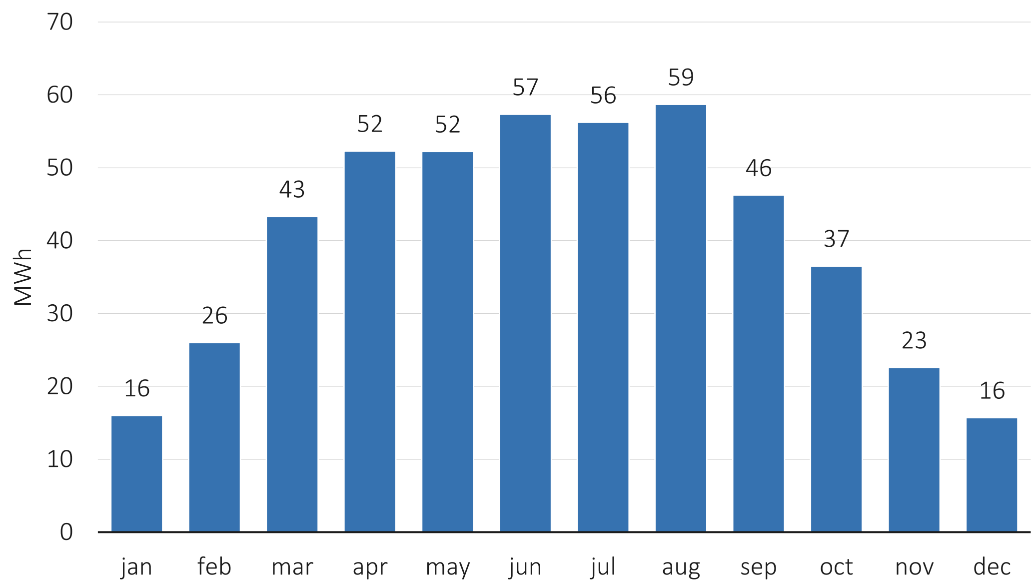
Prosumers that have a maximum effect of more than 400 kW are treated according to procedures given in Article 55 paragraph (3) in the *Regulation on the Connection of Users to Public Electricity Networks* (Autoritatea Naţională de Reglementare în domeniul Energiei, 2023). This regulation gives the steps and procedures necessary to connect the providers' installations to the public electricity grid.

## 3.2 Resource potential

The airport has an area of approximately 52 000 square meters at ground level that is available for installing solar PV panels. In addition, there is an area of 356 square meters on the roof of the administrative building available.

The ground level area is flat with pastures and well suited for hosting PV panels. The surrounding area is also flat and there are no major obstacles that could block the sun. To assess the solar irradiation at the airport, we use the simulation software PVGIS tool from the European Commission. PVGIS uses satellite data to simulate solar radiation at a given coordinate. The monthly average power generation from a 400 kWp system is at the Satu Mare airport is shown in Figure 3.1 below.

Figure 3.1 Monthly average power generation with 400 kWp system.

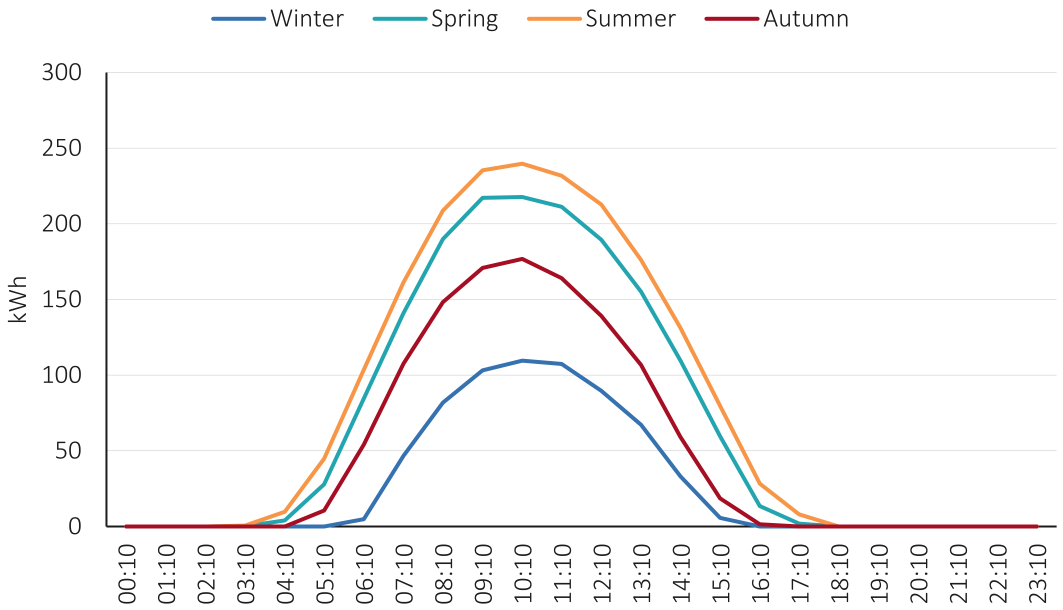



*Source: PVGIS*

Delivered power from the PV panels will be lower than the power produced by the PV cells due to loss in cables, inverters and dust or snow covering the modules. The modules will also lose their efficiency over time. We assume a total system loss of 14%, which is the standard assumption by PVGIS.

Figure 3.1 shows that the power generation varies significantly through the year, reaching peak generation in the summer months of June, July and August. Figure 3.2 shows average hourly power generation in each season.[1]

Figure 3.2 Average hourly power generation with 400 kWp system.




*Source: PVGIS*

The area enables complete freedom in placement of the panels. Thus, we assume that the PV panels are placed facing south, with a fixed slope of 35 degrees.

The area that is required to produce a given amount of power depends on the efficiency of the PV panels and the required spacing between panels to avoid panels casting a shade over each other.

We assume PV modules with 22.6% max efficiency as given in the technical documentation from the providers. Given a 400 kWp system, this implies that the modules cover 1770 square meters. In addition, spacing between modules is needed for maintenance purposes and to avoid panels casting shade over each other.

An upper estimate of the required ground area for a 400 kWp is 10 000 square meters, including the required space between modules. Thus, even for a 1600 kWp system, the required ground area is well below the available 52 000 square meters at the airport, and ground area is not a constraint for PV power generation at the airport.

## 3.3 Economic aspects

Like most investments, there are capital expenditures and operational expenses associated with producing solar energy at Satu Mare International Airport. Since the airport will have the possibility to sell surplus electricity to the grid, the investment is also associated with a potential

[1] Winter includes the months of December, January and February; spring includes March, April and May; summer includes June, July and August; autumn includes September, October and November.

income. These economic aspects are presented below and provide the basis for the business cases presented later, in chapter 4.

### 3.3.1 CAPEX and OPEX

The capital expenditure (CAPEX) and operational expenses (OPEX) associated with installing solar energy at the airport may vary between providers. To give insightful estimates of the costs the airport may incur when investing in a solar installation, we have gathered cost information from a two relevant local providers of solar energy instalments in Satu Mare. They will henceforth be referred to as provider A and provider B.

#### CAPEX

Provider A can deliver the solar panels for an investment cost of 1000 euros per kWp, VAT excluded. This includes all the labor needed to install the modules, the necessary documentation, the structure the panels are mounted on, photovoltaic cables (DC), power cables (AC), the panels (AC and DC), inverters, measuring and monitoring equipment (LOGGER), perimeter fencing, and warranties. The very same delivery can be made by provider B for an investment cost of 647.5 euros per kWp, excluding VAT. The panels are expected to produce upwards of 99 % initial capacity in the first year, before efficiency decreases 0.4% each year throughout their 30-year lifespan. During this period production should stay above 85% of initial capacity with annual maintenance.

Both providers can also deliver energy storage systems, with battery capacities at 161 kWh and 193.5 kWh. The recommended capacity exploitation range for maximizing the battery lifespan is a 95% charging level and a 20% discharging level. At these levels the batteries are expected to endure over 5000 charging cycles. They will, however, experience a 2% decrease in storage capacity each year, leading to a need for replacement after approximately 15 years. In addition to the battery pack, the energy storage system includes smart rack controllers and a Smart PCS (Power Conversion System) for battery monitoring and optimization, inverting currents and managing electricity flow. The investment cost for the 161-kWh storage system is 75 000 euros with provider A, and 59 000 euros from provider B, VAT excluded. For the 193.5-kWh system the investment cost is 90 000 euros with provider A, and 66 000 euros with provider B.

Table 3.1 Capital expenditure

| Instalment | Investment cost provider A (excl. VAT) | Investment cost provider B (excl. VAT) |
|---:|---:|---:|
| PV panels (1 kWp) | 1000 € | 647.5 € |
| Battery 161 kWh | 75 000 € | 59 000 € |
| Battery 193.5 kWh | 90 000 € | 66 000 € |

*Source: Vista Analyse*

#### OPEX

The operational costs are related to the maintenance required to keep the panels and batteries fully functional throughout their lifespan. This could be tasks like fixing occurring problems, cleaning, physical checks and software tests. Provider A states the operational costs of the PV panels to be 12 euros per kWp each year, excluding VAT, while provider B states 6.48 euros per kWp.

For the energy storage systems, the yearly operational costs are the same for the different types of batteries, independent of their individual capacity. This amounts to 2000 euros excluding VAT with provider A. With provider B the yearly operational costs are 660 euros, but only for the first battery. Should more batteries be installed the operational costs for the additional ones are 330 euros per year.

Table 3.2 Operational expenses

| Instalment | Operational costs provider A (excl. VAT) | Operational costs provider B (excl. VAT) |
|---:|---:|---:|
| PV panels (1 kWp) | 12 € | 6.48 € |
| First battery | 2000 € | 660 € |
| Additional battery | 2000 € | 330 € |

*Source: Vista Analyse*

### 3.3.2 Income

The revenue associated with installing photovoltaic panels comes from a combination of reduced electricity costs and income generated by selling surplus electricity to the grid. By producing their own energy, the airport's electricity costs can be reduced by the electricity produced times the electricity price that would otherwise be paid when purchasing from the grid. As of January 2025, the Romanian government has enforced caps on electricity prices to help manage the rising energy costs. According to Article 1 in Emergency Ordinance No. 192/2022, which has been extended to March 31st, 2025, the price for non-household consumers is 0.26 euros per kWh including VAT (Ministerul Justitiei, 2022).

In the hours when production is higher than consumption, the surplus electricity can be stored in batteries, should they also be installed. When consumption is no longer continuously covered by production, the electricity stored in the batteries can then take over as supply source. This further enables avoiding costs from purchasing grid electricity. Should production exceed both consumption and the battery storage capacity, this electricity can be sold back to the grid. Under normal circumstances, the price received from selling electricity to the grid is calculated as the weighted average day-ahead market price for the month in which the electricity was generated. However, the grid operator in Satu Mare informs that at this point there will be a constant price of 0.06 euros per kWh. This will almost certainly not be the case throughout the entire 30-year solar energy production period, but as it is the current first-hand information, the income calculations will be based on this price.

## 3.4 Social and environmental aspects

Besides the fact that solar PVs at Satu Mare International Airport generally would contribute to covering the need for electricity and reducing the airport's operational costs, there are also some social and environmental aspects to be discussed.

If the airport sources all its electricity from the grid, the emissions will be determined by the Romanian energy mix given in Figure 1.2. Both the European Environment Agency and The UNFCCC secretariat (UN Climate Change) publish estimates for $C0_2$ equivalents per kilowatt-hour of electricity. According to the EEA, the greenhouse gas emission intensity of electricity generation in Romania was 0.234 kg $CO_2$eq per kilowatt-hour in 2023 (EEA, 2024), while the UNFCCC's Greenhouse Gas Emissions Calculator estimated 0.2895 kg $CO_2$eq per kilowatt-hour for 2022 (UNFCCC, 2023). Electricity produced by solar energy is considered zero emissions, so every kilowatt-hour produced by photovoltaic panels would decrease the airports $C0_2$ emissions by between 0.234 and 0.2895 kg $CO_2$eq.

Another aspect of power production is air pollution. Air pollution caused by the “traditional pollutants” – particulate matter smaller than 2.5 microns per cubic meter (PM2.5) along with nitrogen dioxide ($NO_2$) and ozone ($O_3$) – is still a serious problem in Europe and Romania. These particles are associated with over 8 million worldwide premature deaths each year, and mainly stem from electricity generation from burning fossil fuel, transportation and the chemical and mining industries (UN Environment Programme, 2023). Though the amounts are low compared to fossil fuel power, air polluting emissions do also occur with power production from some renewable sources, such as geothermal power plants. Solar energy, on the other hand, is not a source of air pollution, meaning solar PVs at Satu Mare International Airport contribute to mitigating these emissions.

# 4 Business case

Based on the information presented in the foregoing chapters we have established multiple options for investments in photovoltaic panels and energy storage (batteries) at Satu Mare International Airport. All investment options, presented below in Table 4.1, involve a 400 kWp photovoltaic system but differ in the amount of storage capacity installed. A capacity of 400 kWp was selected based on current regulations regarding renewable energy production in Romania, as discussed in chapter 3. By staying below the 400 kWp threshold, the airport avoids the need for additional assessments, documentation, and application procedures. The first option includes only photovoltaic panels, with no storage capacity. The following options have increasing amount of storage capacity, up until 935kW, which is sufficient to store almost the entire electricity production, even during high-output summer months.

Table 4.1 Investment options

| | Photovoltaic panels | Storage capacity |
|---|---|---|
| Option 1 | 400 kWp | 0 |
| Option 2 | 400 kWp | 193,5 kWh |
| Option 3 | 400 kWp | 387 kWh |
| Option 4 | 400 kWp | 580,5 kWh |
| Option 5 | 400 kWp | 774 kWh |
| Option 6 | 400 kWp | 935 kWh |

*Source: Vista Analyse*

## 4.1 Investment and maintenance

Table 4.2 outlines the capital expenditure (CAPEX), combining the cost of a 400kWp photovoltaic system and varying battery storage capacities. These numbers are based on the costs described in chapter 3.3.1. The investment cost for the photovoltaic panels remains constant across all options for both providers. However, the total investment cost rises as the electricity storage capacity is increased. Provider A charges a fixed cost of 400 000 euros for the photovoltaic panels, whereas Provider B offers a price of 259 000 euros. Additionally, Provider B also provides lower prices for batteries, making it the cheaper alternative overall.

Table 4.2 Investment cost (CAPEX)

| | Provider A | Provider B |
|---|---|---|
| Option 1 | 400 000 € | 259 000 € |
| Option 2 | 490 000 € | 325 000 € |
| Option 3 | 580 000 € | 391 000 € |
| Option 4 | 670 000 € | 457 000 € |
| Option 5 | 760 000 € | 523 000 € |
| Option 6 | 835 000 € | 582 000 € |

*Source: Vista Analyse*

Both the photovoltaic panels and batteries used for electricity storage require regular maintenance to ensure optimal performance and longevity throughout their expected lifetime. Table 4.3 provides an overview of the total annual maintenance costs for photovoltaic panels and batteries given by the providers. The maintenance cost for the photovoltaic panels remain constant across all options, as the size of the photovoltaic system is the same. The maintenance cost for the batteries, on the other hand, varies depending on the installed storage capacity.

Table 4.3 Annual maintenance cost (OPEX)

| | Provider A | Provider B |
|---|---|---|
| Option 1 | 4 800 € | 2 590 € |
| Option 2 | 6 800 € | 3 250 € |
| Option 3 | 8 800 € | 3 580 € |
| Option 4 | 10 800 € | 3 910 € |
| Option 5 | 12 800 € | 4 240 € |
| Option 6 | 14 800 € | 4 570 € |

*Source: Vista Analyse*

Based on information from Provider A, it is assumed that new batteries will need to be purchased after 15 years. This analysis assumes that the investment cost for the second battery replacement will be the same as the initial investment cost. However, it could be reasonable to anticipate that battery prices will decrease over the next 15 years due to advancements in technology. The photovoltaic panels have a lifetime of 30 years, and it is not assumed that additional investments will be needed in this period.

## 4.2 Revenue

As mentioned in chapter 3.3.2, the revenue associated with installing photovoltaic panels comes from a combination of reduction in electricity costs and income generated by selling excess electricity to the grid. Reduction in electricity costs comes from using the electricity directly and from using electricity stored in batteries. The income from selling electricity is determined by multiplying the excess production by the electricity price set by the grid operator for energy sold back to the grid.

Table 4.4 Annual revenue

| | Reduced electricity costs | Income from selling electricity to the grid | Total revenue |
|---|---|---|---|
| Option 1 | 89 557 € | 6 855 € | 96 412 € |
| Option 2 | 97 082 € | 4 690 € | 101 772 € |
| Option 3 | 103 918 € | 3 112 € | 107 030 € |
| Option 4 | 109 181 € | 1 898 € | 111 079 € |
| Option 5 | 112 944 € | 1 029 € | 113 974 € |
| Option 6 | 113 750 € | 797 € | 114 547 € |

*Source: Vista Analyse*

Table 4.4 summarises the average annual revenue generated from the photovoltaic system and the varying levels of battery storage. The revenue varies from year to year, based on the state of the battery, electricity consumption at the airport and production capacity of the photovoltaic panels. Throughout their 30-year lifetime the panels become 0.4% less efficient each year, and the battery storage capacity decreases by approximately 2% each year, until it reaches about 73% of full capacity in year 15.

As battery storage capacity increases from no storage in Option 1 to 935 kWh in Option 6, the reduction in electricity costs rises simultaneously, from 89 557 to 113 750 euros. The cost reduction that comes from directly using the generated electricity remains constant across all options but increases over time as the airport's electricity consumption grows. The increase is due to the use of stored electricity, which, not surprisingly, increases with the amount of available battery storage. On the other hand, income from selling electricity to the grid decreases as battery storage increases, from close to 7000 euros in option 1 to less than 800 euros in option 6. As storage capacity increases there is less excess electricity to sell, and it is used for own consumption. Total revenue increases with battery storage capacity because the price the airport pays for electricity purchased from the grid is higher than the price received for selling electricity back to the grid. By using stored electricity for own consumption, the airport replaces electricity that would otherwise have been purchased, thereby increasing overall revenue.

## 4.3 Net present value (NPV)

Table 4.5 presents average annual cash flow, and the resulting NPV, calculated over a 30-year period with a discount rate of 10%. While the revenue is higher for options with more storage capacity due to reduced grid-dependency, the higher investment and operational costs diminish NPV for both Provider A and Provider B.

Table 4.5 Annual revenue and net present value

| | **Provider A** | | **Provider B** | |
|---|---|---|---|---|
| | Average cash flow | NPV | Average cash flow | NPV |
| Option 1 | 91 184 € | 466 387 € | 93 822 € | 628 221 € |
| Option 2 | 94 972 € | 394 021 € | 98 522 € | 598 232 € |
| Option 3 | 98 230 € | 317 537 € | 103 450 € | 567 236 € |
| Option 4 | 100 279 € | 230 384 € | 107 169 € | 525 572 € |
| Option 5 | 101 174 € | 132 685 € | 109 734 € | 473 361 € |
| Option 6 | 99 747 € | 30 651 € | 109 977 € | 406 900 € |

*Source: Vista Analyse*

The average annual cash flow accounts for annual revenue, maintenance costs for both photovoltaic panels and storage systems, as well as the additional storage capacity investment required in year 15. The income remains identical between providers, as it is determined by production levels, storage capacity, and the electricity price. However, Provider A's higher annual maintenance costs and investment costs for new batteries result in lower cash flows across all options compared to Provider B.

Table 4.6 Net present value from batteries in isolation

| | Provider A | | Provider B | |
|---|---|---|---|---|
| | NPV of all batteries | NPV of one additional battery | NPV of all batteries | NPV of one additional battery |
| Option 1 | - | - | - | - |
| Option 2 | -72 366 € | -72 366 € | -29 989 € | -29 989 € |
| Option 3 | -148 850 € | -76 484 € | -60 985 € | -30 996 € |
| Option 4 | -236 003 € | -87 153 € | -102 649 € | -41 665 € |
| Option 5 | -333 702 € | -97 699 € | -154 860 € | -52 211 € |
| Option 6 | -435 736 € | -102 034 € | -221 320 € | -66 460 € |

*Source: Vista Analyse*

Table 4.6 describes the net present value of batteries in isolation for both providers, across options. The first column summarises the NPV for total storage capacity in each option and the second column gives the NPV of adding another 195.3 kWh in storage capacity. For both providers, the financial losses associated with investing in storage capacity grow larger as the total storage capacity increases. In option 2, with a storage capacity of 193.5 kWh, the batteries are fully utilised for much of the year, as the excess electricity produced often exceeds the available storage capacity. However, when the storage capacity increases, the batteries are less frequently filled to their full capacity. As a result, the additional revenue generated from increased storage capacity, falls.

## 4.4 Sensitivity analysis

To check the robustness of the net present value we have performed sensitivity analysis. We have investigated the following parameters:

- The charging range of batteries
- The discount rate
- The price of purchased electricity
- The cost of batteries

### 4.4.1 Changing the charging range of batteries

So far, we have assumed that batteries are charged between 20 and 95% for a 75 percentage point interval. In sensitivity calculations we have examined 80%, 85% etc. all the way up to 100%. None of these change ranking of options and the conclusion that a battery by itself is unprofitable.

### 4.4.2 Changing the discount rate

So far, we have assumed a discount rate (also called a rate of return requirement) of 10%. In sensitivity calculations we have experimented with a higher discount rate. A higher discount rate does not change the ranking of options and the conclusion that a battery by itself is unprofitable.

If we reduce the discount rate to 5% a battery becomes profitable in the case of provider B. The reason is that future income (cost reduction) from using a battery in this case gains higher weight, compared to the investment cost of a battery. In the case of provider B, the discount rate must lowered all the way to 1% for a battery to become profitable.

### 4.4.3 Changing the price of purchased electricity

Recall that a battery allows the airport to spend electricity from the battery instead of purchasing electricity from the grid, and it allows to save electricity instead of selling to the grid. The annual income depends on physical conditions such as the charging capacity, and on the price differential between electricity purchased and sold.

If we increase the price of purchased electricity from 0.26 euro/kWh to 0.51 euro/kWh it is profitable to install one battery according to provider A (Table 4.7). This is close to a 100% increase. An increase to 0.66 euro/kWh makes a second battery profitable, and so on. Table 4.7 also shows that for the solar PV installation to be profitable a price of only 0.12 euro/kWh is necessary, according to provider A.

Table 4.7 Electricity price sensitivity, Provider A

| | 0.12 € | 0.51 € | 0.54 € | 0.66 € | 0.86 € | 2.14 € |
|---|---|---|---|---|---|---|
| Option 1 | - | 1 276 577 | 1 388 093 | 1 775 754 | 2 407 581 | 6 580 391 |
| Option 2 | -114 024 | 1 276 577 | 1 398 054 | 1 820 340 | 2 508 602 | 7 054 127 |
| Option 3 | -229 209 | 1 267 323 | 1 398 054 | 1 852 509 | 2 593 201 | 7 484 991 |
| Option 4 | -347 406 | 1 234 097 | 1 372 250 | 1 852 509 | 2 635 256 | 7 804 793 |
| Option 5 | -468 578 | 1 177 174 | 1 320 940 | 1 820 709 | 2 635 256 | 8 014 807 |
| Option 6 | -578 395 | 1 088 661 | 1 234 289 | 1 740 527 | 2 565 618 | 8 014 807 |

*Source: Vista Analyse*

Moving to provider B a price of 0.36-0.37 euro/kWh is required for both one and two batteries to be profitable (Table 4.8). This is close to a 40% increase in price. Table 4.8 also shows that for the solar PV installation to be profitable a price of only 0.07 euro/kWh is necessary, according to provider B.

Table 4.8 Electricity price sensitivity, Provider B

| | 0.07 € | 0.36 € | 0.37 € | 0.45 € | 0.58 € | 1.49 € |
|---|---|---|---|---|---|---|
| Option 1 | - | 963 964 | 1 001 750 | 1 254 180 | 1 665 601 | 4 610 625 |
| Option 2 | -86 101 € | 963 964 | 1 005 126 | 1 280 102 | 1 728 271 | 4 936 345 |
| Option 3 | -169 228 € | 960 828 | 1 005 126 | 1 301 049 | 1 783 358 | 5 235 814 |
| Option 4 | -252 707 € | 941 511 | 988 324 | 1 301 049 | 1 810 743 | 5 459 223 |
| Option 5 | -336 536 € | 906 198 | 954 912 | 1 280 342 | 1 810 743 | 5 607 444 |
| Option 6 | -413 480 € | 845 341 | 894 686 | 1 224 328 | 1 761 595 | 5 607 444 |

*Source: Vista Analyse*

### 4.4.4 Investment cost

Higher income from batteries makes them profitable, but lower cost does the same. For one battery to be profitable the investment cost must be no higher than 31 612 euros for provider A and 41 804 for provider B. That means that the investment cost would have to be reduced by 58 388 euros for Provider A (65% reduction) and 24 196 euros for provider B (35% reduction).

# 5 Next steps

This pre-feasibility study has shown that a 400 kWp solar PV installation at Satu Mare International Airport is profitable. The eventual profit of one or more batteries will depend on the cost of the installation and the price differential at the time of purchase. At current prices and costs batteries do not seem to be profitable. To put it differently, the installation is likely to be more profitable if it is a stand-alone, without batteries.

The profitability of the PV installation is robust. That is, it remains even if the cost of the installation is significantly higher, or the volume of production is significantly lower, or the rate of return requirement is significantly higher. To identify the cost of installation, we have collected information from key suppliers. To identify the production potential, we have used the state-of-the-art software PVGIS. As a next step it will be worthwhile to compare our estimates with data from nearby, existing solar PV installations, of which there is at least one. A further next step is to detail the project according to the requirements of relevant financial institutions, and relevant authorities.

The robust profitability of a 400 kWp solar PV installation begs the question of whether the airport should install higher capacity. As noted in chapter 3.1 the regulation pertaining to installations above 400 kWp is more complicated than below 400 kWp. Still, an installation of higher capacity might be worthwhile to consider.

The current plans for modernization and expansion of the airport do not include modernization of the administrative building. Including the administrative building will complete the modernization, and the administrative building will surely be modernized at some point. Additional electricity production could be used for this purpose.

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# Appendices

# A Estimated energy consumption

In this appendix we present the full table of estimated energy consumption per month from 2025 to 2035. The estimates serve as the foundation for Figure 2.4 in the report.

## A.1 Estimated monthly energy consumption

As described in chapter 2.2.2, the estimates for future energy consumption at the airport terminals are based on data provided by the Satu Mare International airport management. Taking historic number of passengers (2019 to 2023), estimated number of passengers (2025 to 2035) and the floor area of the old terminal into consideration, we have conducted a regression analysis on monthly electricity consumption of the airport (2019 to 2023).

Table A.5.1 Estimated monthly energy consumption (MWh)

| | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| jan | 94,14 | 94,49 | 94,88 | 95,60 | 96,25 | 97,00 | 97,87 | 98,86 | 100,00 | 101,31 | 102,82 |
| feb | 75,41 | 75,72 | 76,08 | 76,73 | 77,32 | 78,00 | 78,78 | 79,68 | 80,72 | 81,91 | 83,27 |
| mar | 72,21 | 72,52 | 72,86 | 73,50 | 74,08 | 74,74 | 75,50 | 76,38 | 77,39 | 78,55 | 79,88 |
| apr | 61,02 | 61,36 | 61,75 | 62,48 | 63,13 | 63,88 | 64,74 | 65,73 | 66,87 | 68,18 | 69,69 |
| may | 62,12 | 62,52 | 62,96 | 63,79 | 64,53 | 65,39 | 66,38 | 67,51 | 68,82 | 70,32 | 72,05 |
| jun | 67,01 | 67,39 | 67,83 | 68,64 | 69,37 | 70,21 | 71,18 | 72,29 | 73,57 | 75,04 | 76,73 |
| jul | 72,52 | 73,05 | 73,65 | 74,77 | 75,77 | 76,93 | 78,26 | 79,79 | 81,55 | 83,58 | 85,91 |
| aug | 73,46 | 74,07 | 74,75 | 76,02 | 77,16 | 78,47 | 79,98 | 81,72 | 83,72 | 86,01 | 88,65 |
| sep | 69,44 | 69,96 | 70,54 | 71,63 | 72,61 | 73,73 | 75,03 | 76,51 | 78,22 | 80,19 | 82,45 |
| oct | 68,42 | 68,82 | 69,27 | 70,10 | 70,85 | 71,71 | 72,70 | 73,83 | 75,14 | 76,65 | 78,38 |
| nov | 86,34 | 86,67 | 87,03 | 87,72 | 88,34 | 89,05 | 89,86 | 90,80 | 91,88 | 93,12 | 94,55 |
| dec | 89,51 | 89,85 | 90,22 | 90,92 | 91,56 | 92,28 | 93,12 | 94,08 | 95,18 | 96,45 | 97,91 |
| Year | 891,59 | 896,42 | 901,82 | 911,90 | 920,97 | 931,40 | 943,40 | 957,20 | 973,07 | 991,32 | 1012,30 |

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