ELECTRIC MOBILITY AND TOURISM – DESIGNING A MODEL FOR CHARGING INFRASTRUCTURE IN SEASONAL TOURISM REGIONS

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The growing share of battery electric vehicles (BEVs) poses new challenges for tourism regions, which are typically characterized by strong seasonality. Charging infrastructure must be sufficiently dimensioned to meet peak demand during the high season, while utilization drops sharply in the low and off-season, raising concerns about economic viability. This paper develops a modeling framework that calculates a seasonal charging coverage ratio and integrates an economic efficiency analysis. Using a case study of a summer destination on the southern European coast, the model quantifies seasonal charging demand, infrastructure capacity, and key economic parameters. The results reveal a structural imbalance: demand during the high season approaches infrastructure capacity, while extended periods of low demand create significant overcapacity and insufficient utilization. Consequently, the charging infrastructure generates an overall annual loss. The proposed modeling framework provides a transferable analytical framework that supports evidence-based charging infrastructure planning in highly seasonal tourism destinations.

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1 Introduction

The transition to electric mobility is accelerating. In September 2025 alone, global sales of electric cars and plug-in hybrids rose by 26 percent to a record 2.1 million vehicles. In Germany, sales of purely electric cars rose by 45 percent in the third quarter, and in Spain by as much as 100 percent (Schmidt, 2025). It is therefore foreseeable that this will have consequences for tourist destinations that are usually reached by car, such as the coastal regions of southern Europe or ski resorts in the Alps. These developments require the expansion of charging infrastructure needed to supply electric vehicles. According to recent studies, this charging infrastructure is of great importance, as awareness of sustainable travel is growing steadily and a well-developed charging infrastructure is becoming increasingly important as a competitive factor for holiday destinations (Bornefeld, 2023). For tourist destinations, the question now arises as to the extent to which such a charging infrastructure should be expanded in terms of the number of charging options and the respective power output of the charging facilities against the backdrop of the typical annual seasonal cycle (high season, low season, off-season).

The aim is to address this problem by developing a model that uses specific parameters to calculate a “charging coverage ratio” that indicates the utilization of the charging infrastructure per season. In a further step, the economic efficiency of the charging infrastructure is also calculated. For this purpose, an Excel-based data collection and analysis tool (Charging Station Calculator Tool, abbreviated: CSC tool) is used. The contribution lies in linking seasonal demand modeling with economic viability assessment in a single framework.

2 Theoretical background/Literature review

Tourism is an important economic and employment sector both in Europe and worldwide. In 2025, the travel and tourism sector is expected to contribute nearly €1.9 trillion to the EU's GDP, accounting for 10.5% of the EU economy. The number of people employed is expected to reach almost 26 million, accounting for 12% of all jobs in the EU – a clear sign of the growing importance of the sector (WTTC, 2025). For many European countries, tourism is one of the most important economic factors.

According to Eurostat, the share of GDP generated by international tourism in selected EU countries in 2023 was around 18.7% in Croatia, around 10.6% in Cyprus, around 9.6% in Malta, and around 9.5% in Portugal (Eurostat, 2025a). Looking at individual holiday regions, a strong seasonal pattern emerges. In one in six EU regions, more than 40% of annual overnight stays occur in just two months of the high season, with this seasonal effect being particularly pronounced in coastal regions (Eurostat, 2025b). When looking at the modal split, i.e., the choice of transport mode, an average view is not very meaningful, as some destinations (e.g., islands) are usually reached by plane or ship rather than by car. However, it is striking that some holiday destinations are characterized by above-average car travel, including Croatia with 70% and Slovenia with 69% (Eurostat, 2025c).

Based on a study by the European Automobile Manufacturers' Association (ACEA), a distinction should be made between private and public charging (ACEA, 2022). Private charging is restricted in terms of access, either by private ownership or a hotel. Public charging stations are freely accessible, except for semi-public charging stations (e.g., in parking garages). Depending on the power output of public charging stations, a distinction can be made between slow or normal charging (alternating current charging, charging power approx. 4–22 kW, hereinafter referred to as normal (AC) charging), fast charging (direct current charging, charging power approx. 150 kW, hereinafter referred to as fast (DC) charging) and ultra-fast charging (high-power charging (HPC), charging power approx. 400 kW). A recent study by the International Energy Agency (IEA, 2025) provides an overview of the current situation and an outlook for the near future of charging infrastructure expansion.

3 Methodology

The steps for performing calculations with the CSC tool are explained below. Two Excel worksheets are used for each of the two calculation areas, “Charging coverage ratio” and “Economic efficiency”, which are supplemented by additional worksheets with supplementary parameters. For the sake of simplicity, the specific assignment to the individual Excel areas is not discussed below. To increase the informational value of the explanations, sample data from a modeled case study is used below. The case study is based on the assumption of a summer destination on the coast of Southern Europe. The case study serves as an exemplary scenario and does not claim to be statistically representative. Instead, the model aims to demonstrate a transparent analytical structure that can be adapted to different tourism destinations by adjusting a limited set of input parameters. The model is based on a set of simplifying assumptions that aim to ensure transparency and reproducibility rather than exact prediction accuracy. Key assumptions include constant average charging volumes, simplified seasonal utilization rates, and a stylized representation of tourist behavior. These assumptions are intentionally chosen to highlight structural relationships between demand, capacity, and economic performance. The model does not aim to predict exact real-world outcomes but rather to illustrate structural relationships. Therefore, results should be interpreted as scenario-based insights rather than precise forecasts.

3.1 Guest Calculation

The case study does not represent a specific destination but reflects a stylized Mediterranean summer tourism region based on typical accommodation capacities and seasonal occupancy patterns reported in European tourism statistics. The objective is not statistical representation but the illustration of structural relationships between seasonal demand and infrastructure capacity.

The starting point for this is the calculation of bed capacity, which is determined using the parameters "number of accommodation establishments" (n=726) and "average capacity of accommodation establishments (in beds, n=30)". For this case study, a bed capacity of 21,780 beds is therefore assumed. This bed capacity is utilized differently in the defined vacation periods (high season, low season, and off-season). The average length of stay for EU citizens in other EU countries is approximately seven days (Eurostat, 2025c). For reasons of model simplification, all visitors are assumed to have an average length of stay of seven days. This assumption allows for a consistent derivation of weekly arrival and loading requirements. By assuming an average bed occupancy rate per season, it is possible to determine the number of guests arriving in the destination region per week.

Table 1: Guest calculation

Season type	High season	Low season	off-season	Total
Season weeks	16	22	14	52
Length of week in days	7	7	7	
Average holiday stay period (in days)	7	7	7	
Maximum tourist bed capacity	21,780	21,780	21,780	
Bed capacity utilization rate	70%	30%	1%	
Arriving guests per week	15,246	6,534	218	

Source: author's compilation

The very low bed occupancy rate in the off-season deliberately reflects a scenario in which only a few businesses are open all year round.

3.2 BEV calculation

In this section, the calculated number of visitors is used to estimate the number of battery electric vehicles (BEVs) that will require charging infrastructure during a season. The calculation of the number of visitors arriving by car is based on the modal split parameter for passenger cars in Germany (Statista, 2025a). For the different seasons, an assumption is made about the number of people in the vehicle. The average number of people per vehicle is statistically 1.46 (Bundestag, 2018). For the case study, different assumptions are made. The values used are significantly higher than the statistical average, as tourist trips are usually made with several people per vehicle, e.g., families with children. These parameters are used to determine the number of vehicles arriving in the destination each week. The 20% share of battery electric vehicles (BEVs) is based on current European market trends and is used as a scenario parameter rather than a forecast value (Statista, 2025b). This now allows the number of BEVs arriving each week to be calculated. Considering private charging processes, the share of BEVs that require public charging infrastructure is determined.

The proportion of private charging is estimated and mainly relates to charging stations at accommodation providers (e.g., hotels). Due to the closure of hotels outside the high season, this value varies depending on the season. This results in a value that describes the average number of BEVs present at the same time that require public charging network during a typical stay.

Table 2: BEV calculation

Season type	High season	Low season	off-season
Arriving guests per week	15,246	6,534	218
Modal split (private car)	80%	80%	80%
Guests arriving with vehicles	12,197	5,227	174
Persons per vehicle	4	3	2
Arriving vehicles per week	3,049	1,742	87
Share of BEV	20%	20%	20%
Arriving BEVs per week	610	348	17
Share of private charging	20%	10%	5%
Share of public charging	80%	90%	95%
Average number of BEVs simultaneously present and requiring public charging infrastructure per week	**488**	**314**	**17**

Source: author's compilation

3.3 Charging calculation

This section calculates how many charging processes are required per season. To do this, a value is first assigned that represents charging processes for vacation trips per visit. The values assumed for this study refer to a summer destination. For a typical winter destination, such as a week's skiing holiday, it would be appropriate to reduce these assumptions accordingly, as ski buses etc. are used. An additional charging process is assumed for the return journey. Charging demand is primarily determined by the full charge required for the return journey and less by the activities during the stay. The sum of both values is then multiplied by the number of BEVs to obtain the total number of average charging processes for all BEVs (per week/per season). Even in the off-season, there is still a minimum charging requirement, as a full charge is necessary for the return journey regardless of the intensity of the stay.

Based on an assumed average charging volume per charging process, the total seasonal energy requirement can be derived by multiplying the number of charging processes by the average energy transferred per process.

Table 3: Charging calculation

Season type	High season	Low season	off-season
Average number of BEVs simultaneously present and requiring public charging infrastructure per week	488	314	17
Charging processes for holiday trips	1.0	0.7	0.3
Full charge for return trip	1.0	1.0	1.0
Calculated average charging processes per BEV	2.0	1.7	1.3
Total number of required charging processes per week	976	533	22
Total number of required charging processes per season	**15,612**	**11,730**	**301**
Average charging capacity (amount of electricity transferred) (in kWh)	62.5	62.5	62.5
Energy requirement per week in kWh	60,984	33,323	1,345
Energy requirement per season in kWh	**975,744**	**733,115**	**18,829**

Source: author's compilation

The assumptions regarding charging frequency and energy demand per charging process are intentionally simplified in order to create a transparent and reproducible modeling structure. They represent plausible average values derived from current EV battery capacities and typical driving ranges rather than precise behavioural forecasts.

3.4 Public charging infrastructure and capacity calculation

To determine the charging coverage ratio, the capacity of the public charging infrastructure must be calculated on the supply side. To do this, both the theoretical and the realistically achievable charging capacity per season must be modeled.

The calculation is performed separately for normal (AC) charging and fast (DC) charging. High-power charging (HPC) is not considered for reasons of simplification. Seasonal assumptions regarding daily operating hours are made for charging. Although a day consists of 24 hours, it is unrealistic to assume continuous use of the public charging infrastructure. Therefore, a reduced number of effective hours of use per day is defined for each season, reflecting typical charging behavior during the day and lower demand at night.

Table 4: Public charging general parameters

Season type	High season	Low season	off-season
Hours per day	24	24	24
Usage hours of a public charging station	12	10	8
Usage hours rate in %	50%	42%	33%

Source: author's compilation

For the case study, the infrastructure was dimensioned so that the demands of the high season could be covered with a moderate safety margin.

An average charging capacity was assumed for each charging point, resulting in a theoretical charging capacity or charging potential per day. However, this theoretical capacity does not reflect actual operating conditions. Therefore, an average utilization factor is introduced to account for fluctuations in demand, idle times, and operational inefficiencies. Multiplying the theoretical capacity by this utilization factor gives the realistic daily charging potential per charging point.

The realistic total energy supply per season is then determined by multiplying the realistic daily capacity of a charging station by the number of installed charging stations and the number of weeks in the season.

In addition to the energy-based capacity calculation (kWh per season), the number of possible charging processes is determined. This is calculated by dividing the effective daily hours of use by the average charging time per vehicle. The resulting theoretical number of charging processes per charging point is then adjusted by a seasonal utilization factor to obtain a realistic estimate of daily charging processes. This value can then be extrapolated to weekly and seasonal values.

The model therefore evaluates public charging capacity based on two dimensions:

1. Energy potential (in kWh)
2. Operational capacity (number of charging processes)

This dual perspective ensures consistency with the previously calculated demand indicators (energy demand and charging processes) and enables the derivation of the charging coverage ratio as the ratio between seasonal demand and seasonal supply.

For normal (AC) charging, 100 installed charging points are assumed, each with a charging capacity of 11 kWh.

Table 5: Normal (AC) charging parameters

Season type	High season	Low season	off-season
Ad 1) Calculating Energy potential			
Number of public charging points: Normal (AC) charging	100	100	100
Average charging capacity (amount of electricity transferred) (in kWh) for one charging station	11	11	11
Theoretical charging potential (kWh/day)	132	110	88
Average utilization factor in %	30%	20%	10%
Realistic charging potential (kWh/day)	39.6	22.0	8.8
Realistic charging potential (kWh/day) for all charging points	3,960	2,200	880
Realistic charging potential (kWh/day) for all charging points per week	27,720	15,400	6,160
Realistic charging potential in kWh for all charging points per season	**443,520**	**338,800**	**86,240**
Ad 2) Calculating Operational capacity			
Average charging time (in hours)	4.0	4.0	4.0
Theoretical charging operations per day per charging point	3.0	2.5	2.0
Average utilization factor in %	30%	30%	30%
Operational capacity for one charging point	0.9	0.8	0.6
Operational capacity for all charging points	90.0	75.0	60,0
Operational capacity for all charging points per week	630,0	525,0	420,0
Operational capacity (for all charging points per season	**10,080.0**	**11,550.0**	**5,880.0**

Source: author's compilation

For fast (DC) charging, a value of 10 charging stations is assumed, each with a charging capacity of 150 kWh.

Energy-based and operation-based capacities may deviate slightly because average charging volumes and charging times vary between vehicles.

Table 6: Fast (DC) charging parameters

Season type	High season	Low season	off-season
Ad 1) Calculating Energy potential			
Number of public charging points: Fast (DC) charging	10	10	10
Average charging capacity (amount of electricity transferred) (in kWh) for one charging station	150	150	150
Theoretical charging potential (kWh/day)	1,800	1,500	1,200
Average utilization factor in %	30%	30%	30%
Realistic charging potential (kWh/day)	540	450	360
Realistic charging potential (kWh/day) for all charging points	5,400	4,500	3,600
Realistic charging potential (kWh/day) for all charging points per week	37,800	31,500	25,200
Realistic charging potential in kWh for all charging points per season	**604,800**	**693,000**	**352,800**
Ad 2) Calculating Operational capacity			
Average charging time (in hours)	0.5	0.5	0.5
Theoretical charging operations per day per charging point	24.0	20.0	16.0
Average utilization factor in %	30%	20%	10%
Operational capacity for one charging point	7.2	4.0	1.6
Operational capacity for all charging points	72.0	40.0	16.0
Operational capacity for all charging points per week	504.0	280.0	112.0
Operational capacity (for all charging points per season	**8,0640**	**6,160.0**	**1,568.0**

Source: author's compilation

3.5 Charging coverage ratio

The charging coverage ratio indicates the relationship between charging demand and available public charging capacity. It is calculated by comparing the previously determined seasonal charging demand (in terms of energy requirements and number of charging processes) with the realistically achievable charging supply of the installed infrastructure. The charging coverage ratio is a new parameter that has been developed specifically for seasonal destinations.

Two dimensions are considered:

1. **Energy-based Charging coverage ratio**

$$\text{Coverage ratio}_{energy} = \frac{\text{Realistic charging potential (kWh/per season)}}{\text{Energy requirement (kWh/season)}}$$

2. Operation-based Charging coverage ratio

$$\text{Coverage ratio}_{operations} = \frac{\text{Realistic charging operations per season}}{\text{Required charging processes per season}}$$

Unlike conventional infrastructure planning metrics that focus solely on installed capacity or peak load estimations, the charging coverage ratio integrates seasonal demand fluctuations with realistically achievable operational capacity. This allows infrastructure adequacy to be evaluated under strongly varying seasonal demand conditions, which are typical for tourism destinations.

A ratio below 100% indicates insufficient charging capacity in the respective season, while a ratio above 100% indicates excess infrastructure capacity.

This dual perspective allows a differentiated assessment of the adequacy of the infrastructure. While the energy-based ratio reflects the ability to meet total electricity demand, the operation-based ratio captures potential bottlenecks caused by limited charging points or insufficient handling capacities. Both indicators are therefore necessary to assess seasonal bottlenecks and overcapacity effects.

Table 7: Charging coverage ratio

Season type	High season	Low season	off-season
Realistic charging potential in kWh for all Charging points per season	1,048,320	1,031,800	439,040
Energy requirement per season in KwH	975,744	733,115	18,829
absolute deviation	72,576	298,685	420,211
Energy-based Charging coverage ratio	**107%**	**141%**	**2,332%**
Operational capacity for all charging points per season	18,144	17,710	7,448
Total number of required charging processes per season	15,612	11,730	301
absolute deviation	2,532	5,980	7,147
Operation-based Charging coverage ratio	**116%**	**151%**	**2,472%**

Source: author's compilation

During peak season, the coverage ratio for electricity capacity is slightly above 100%. This means that, mathematically speaking, all demand can be met during the main season. The same applies to the low season, although the coverage ratio significantly exceeds 100%. However, there is a dramatic overcapacity in the off-season, which is more than twenty times higher than in the peak season. The process-oriented calculation yields roughly the same picture. Good coverage in the peak and off-season is offset by very high overcapacity in the off-season.

4 Efficiency

In addition to the capacity analysis, an economic efficiency assessment of the charging infrastructure is carried out. The profitability calculation is based on a partial cost approach, distinguishing between variable electricity procurement costs and fixed infrastructure-related costs. This structure enables a transparent assessment of seasonal profitability while maintaining consistency with the previously derived demand data. Other cost components such as grid fees or land costs were deliberately not considered, as the focus is on structural economic efficiency.

Two important parameters determine the economic outcome. First, the electricity purchase price is assumed to be €0.38 per kWh. This value reflects a realistic procurement price under current European market conditions and considers the volatility of wholesale electricity markets. Second, seasonal electricity demand is derived directly from the charging demand model presented in Section 3, ensuring methodological consistency between the technical capacity analysis and the financial assessment.

Table 8 summarizes the basic economic parameters. The seasonal electricity demand corresponds to the calculated charging energy demand per season, which forms the basis for the subsequent yield and cost calculations. By combining energy demand volumes with procurement prices and assumptions about infrastructure costs, the model enables a seasonally differentiated profitability analysis. It is assumed that the majority of charging (85%) will be normal (AC) charging, with the remaining 15% being fast (DC) charging. It is also assumed that sales prices will fluctuate seasonally and that there will be a price difference between AC and DC charging.

Table 8: Basic parameters for efficiency

Season type	High season	Low season	off-season
Purchase price of electricity in Euro/kWh	0.38	0.38	0.38
Electricity demand in kWh	975,744	733,115	18,829
Normal (AC) charging			
Charging share in % Normal (AC) charging	85%	85%	85%
Charging volume Normal (AC) charging per period	829,382	623,148	16,004
Sales price of electricity	0.62	0.55	0.49
Fast (DC) charging			
Charging share in % Fast (DC) charging	15%	15%	15%
Charging volume Fast (DC) charging per period	146,362	109,967	2,824
Sales price of electricity	0.82	0.72	0.62

Source: author's compilation

The electricity procurement price should be interpreted as a scenario parameter rather than a fixed market value. The sensitivity examples presented in the discussion illustrate how changes in electricity prices or infrastructure size influence the economic results.

4.1 Efficiency of Normal (AC) charging

The first step is to determine the fixed cost structure of the normal (AC) charging infrastructure. The calculation includes investment costs (hardware and installation), economic life, annual maintenance costs, backend and payment system costs, and capital costs that reflect the opportunity costs of the invested capital. These components are aggregated to determine the annual fixed costs per charging point.

To ensure seasonal comparability, annual fixed costs are distributed proportionally to the duration of each season. This proportional distribution reflects the fact that infrastructure capacity must be maintained throughout the year regardless of the actual degree of utilization. Consequently, fixed costs remain structurally binding even in periods of low demand.

As Table 9 shows, the dominant cost driver for normal (AC) charging infrastructures is the large number of installed charging points (n = 100). Although the fixed costs per charging point appear moderate on an annual basis, the total seasonal fixed cost burden becomes significant when multiplied by the installed capacity. This structural characteristic plays a decisive role in the profitability assessment of off-peak seasons.

Table 9: Normal (AC) charging fixed costs

Season type	High season	Low season	off-season	Total
Sum of fixed costs per charging point p.a.	4,050	4,050	4,050	
Proportionate sum of fixed costs per charging point per period	1,246	1,713	1,090	4,050
Number of charging points	100	100	100	
Total of actual fixed costs all charging points per period in Euro	124,615	171,346	109,038	405,000

Source: author's compilation

Based on the fixed cost distribution shown above, the seasonal profitability of normal (AC) charging can now be assessed. Revenue per season is calculated by multiplying the AC charging volume by the respective seasonal sales price. Variable costs consist exclusively of electricity procurement costs and are therefore directly proportional to the charging volume.

The contribution margin corresponds to the difference between seasonal revenues and electricity procurement costs. It reflects the operating profitability of AC charging before taking infrastructure-related fixed costs into account. As shown in Table 10, the high season generates the largest positive contribution margin due to higher utilization and higher charging volumes.

Table 10: Normal (AC) charging profit calculation

Season type	High season	Low season	off-season	Total
Turnover p.a.	514,217	342,731	7,842	864,790
./. Variable costs p.a.	315,165	236,796	6,082	558,043
Contribution margin	199,052	105,935	1,760	306,747
./. Proportionate sum of fixed costs per charging point per period	124,615	171,346	109,038	405,000
Profit/Loss	**74,436**	**-65,411**	**-107,278**	**-98,253**

Source: author's compilation

However, after deducting the proportionately allocated fixed costs, the seasonal imbalance becomes clear. While the high season remains clearly profitable, the low season already leads to a deficit and the off-season to an even more significant loss. This result underscores the structural challenge of infrastructures with high fixed costs in a highly seasonal demand environment. Even though charging electric cars generates positive contribution margins in all seasons, insufficient utilization outside peak times prevents full cost recovery on an annual basis.

4.2 Efficiency of fast (DC) charging

The proportion of fast (DC) charging is derived as a supplement to normal (AC) charging, based on the assumed charging behavior of visitors. In this case study, DC charging accounts for 15% of the total seasonal charging volume. Although DC charging accounts for a smaller share of the total energy demand, it plays a strategically important role due to higher charging speeds and time-critical demand patterns, especially during arrival and departure times.

The fixed cost structure of fast (DC) charging infrastructure differs significantly from that of normal (AC) charging infrastructure. Due to higher charging capacities and more complex technical requirements, the investment costs per charging point are significantly higher. In addition to the costs for hardware and installation, annual depreciation, maintenance costs, backend and payment system costs, and capital costs are also taken into account here.

As Table 11 shows, the annual fixed costs per DC charging station are significantly higher than for AC charging stations. However, since the number of DC charging stations installed is comparatively low (n = 10), the total seasonal fixed cost burden remains below that of a normal (AC) charging infrastructure. Nevertheless, the higher capital intensity of DC charging stations increases the financial risk in times of low utilization.

Table 11: Fast (DC) charging fixed costs

Season type	High season	Low season	off-season	Total
Sum of fixed costs per charging point p.a.	12,825	12,825	12,825	
Proportionate sum of fixed costs per charging point per period	3,946	5,426	3,453	12,825
Number of charging points	10	10	10	
Total of actual fixed costs all charging points per period in Euro	39,462	54,260	34,529	128,250

Source: author's compilation

Based on the fixed cost allocation, the seasonal profitability of fast (DC) charging can now be assessed. The calculation is performed in the same way as for normal (AC) charging profitability.

Due to the higher sales prices per kWh, DC charging achieves comparatively high contribution margins per unit of energy supplied. As shown in Table 12, the high season achieves a solid positive contribution margin that significantly exceeds the allocated fixed costs. However, the low season already shows a deficit, which widens further in the off-season.

Table 12: Fast (DC) charging profit calculation

Season type	High season	Low season	off-season	Total
Turnover p.a.	120,017	79,176	1,751	200,944
./. Variable costs p.a.	55,617	41,788	1,073	98,478
Contribution margin	64,399	37,389	678	102,466
./. Proportionate sum of fixed costs per charging point per period	39,462	54,260	34,529	128,250
Profit/Loss	**24,938**	**-16,871**	**-33,851**	**-25,784**

Source: author's compilation

Although DC infrastructure requires significantly higher investment per charging station, these high capital costs are partially offset by higher margins during periods of high demand. Similar to AC charging, however, underutilization during off-season months reduces overall profitability and increases financial risk.

4.3 Total Efficiency

The summary of seasonal results for AC and DC charging clearly shows the overall economic performance of the charging infrastructure. Table 13 summarizes the combined contribution margins and fixed costs for all seasons.

Table 13: Total efficiency

Season type	High season	Low season	off-season	Total
Sum of contribution margins	263,451	143,324	2,438	409,213
Sum of fixed costs	164,077	225,606	143,567	533,250
Profit/Loss	**99,374**	**-82,282**	**-141,129**	**-124,037**

Source: author's compilation

The results clearly show a pronounced seasonal imbalance. The high season generates a profit of €99,374, which is primarily attributable to high occupancy rates and sufficient energy consumption to cover fixed infrastructure costs. In contrast, the low season already shows a significant deficit, which expands further in the off-season. When all seasons are combined, the charging infrastructure causes an annual loss of approximately €124,037. This result highlights the structural vulnerability of charging infrastructure in highly seasonal tourist destinations. While peak periods can generate reasonable margins, longer periods of low utilization negatively impact annual profitability.

The results show that profitability is heavily dependent on capacity utilization and electricity procurement costs. Even moderate increases in electricity procurement prices or slight declines in demand can push the annual result further into the red. As a result, seasonal destinations face a structural conflict of objectives between ensuring sufficient charging capacity during peak periods and avoiding overinvestment, which leads to underutilization during the rest of the year.

In addition to the base scenario, sensitivity scenarios can be analyzed to illustrate how changes in key parameters affect financial results. For example, if the purchase price of electricity is reduced by 10% and selling prices are increased by 10%, the overall result becomes positive at €48,189.

5 Results

The model results clearly illustrate the structural challenges associated with expanding the infrastructure in highly seasonal tourism regions. The analysis of charging coverage shows a pronounced asymmetry between peak and off-peak times. In the high season, charging demand is close to available capacity. In contrast, the low season shows significant overcapacity.

From an economic perspective, this imbalance directly leads to financial risk. While sufficient contribution margins are achieved during the high season to cover fixed costs and generate seasonal profits, the low season and off-season remain structurally loss-making due to ongoing fixed infrastructure costs combined with low occupancy rates. As a result, the annual result is negative despite strong performance in the peak months.

These results highlight a fundamental trade-off: ensuring sufficient charging capacity to maintain service quality and visitor satisfaction during peak load times inevitably leads to underutilization during longer periods of low demand. Relying exclusively on private charging facilities (e.g., hotel-based charging options) seems unrealistic for meeting peak demand. At the same time, oversizing public infrastructure to eliminate seasonal bottlenecks can undermine economic sustainability. Although private charging infrastructure at accommodation facilities may cover a part of the demand, relying exclusively on private charging would require unrealistically high installation rates across all accommodation providers and would therefore not eliminate the need for public infrastructure. The model thus shows that seasonal tourist destinations face a double challenge: they must ensure reliable charging availability during the high season while also ensuring long-term profitability throughout the year.

From a practical perspective, the model can support destination managers and local authorities in evaluating different infrastructure sizing strategies and pricing models. It provides a transparent decision-support tool to balance service quality during peak periods with long-term economic sustainability.

6 Discussion

The results of this study highlight the structural tension between infrastructure adequacy and economic profitability in highly seasonal tourism regions. The model shows that ensuring sufficient charging capacity during peak periods inevitably leads to overcapacity and insufficient utilization during longer periods of low demand. This imbalance poses a strategic challenge for the management of tourist destinations and local decision-makers. Consequently, charging infrastructure planning in tourism regions cannot be treated solely as a technical infrastructure problem but must be integrated into broader regional development and mobility strategies. Simple corrective measures such as reducing the number of charging stations or increasing electricity prices are not necessarily viable solutions. Reducing infrastructure capacity can compromise service quality during peak season and potentially impact visitor satisfaction and the competitiveness of the destination. Conversely, significant price increases could deter electric vehicle users and conflict with overall sustainability goals. Instead, a more adaptable and data-driven approach seems appropriate. One possible strategy is to implement a phased infrastructure development model in conjunction with continuous monitoring of user satisfaction and usage intensity. The collection of empirical data - for example, through user surveys, utilization tracking, and analysis of charging behavior - would enable evidence-based adjustments to the scope of the infrastructure and the charging mix (normal (AC) charging vs. fast (DC) charging). The preference structure between normal (AC) charging and fast (DC) charging requires special attention. Even though charging time may be less critical in a vacation context compared to everyday mobility, convenience and flexibility can still influence user satisfaction. Future research should therefore incorporate behavioral data to refine demand assumptions and better align infrastructure planning with actual usage patterns.

Ultimately, the results suggest that seasonal charging infrastructures should not be evaluated solely based on their short-term profitability. Rather, they must be understood as part of a broader location strategy that balances service reliability, sustainability goals, and long-term economic resilience. However, it should also be noted that the model presented contains numerous levers in the form of parameter values. An example scenario is considered to illustrate the sensitivity of the model:

- Halving the number of charging stations to 50 normal (AC) charging stations and 5 fast (DC) charging stations would have a positive effect on profitability, as the annual result would increase to €142,588. However, this would be at the expense of the charging coverage ratio, which would fall well below 100% in both the high and low seasons. For the peak season, charging coverage would be only 54% and process coverage only 58%.

The sensitivity example shows that although profitability can change significantly, the fundamental seasonal structural problem remains. The sensitivity examples once again demonstrate the performance of the model developed, namely the ability to translate changes in parameters directly into critical results in terms of meeting customer needs and profitability.

7 Conclusions

This paper develops and applies a structured modeling framework to assess the adequacy and cost-effectiveness of charging infrastructure in highly seasonal tourism destinations. By integrating a demand-driven charging coverage ratio with a partial cost-benefit analysis, the model enables a comprehensive assessment of both technical capacity and financial sustainability. The case study shows a pronounced seasonal imbalance. While demand in the high season approaches capacity limits, longer periods of low demand, especially in the off-season, cause significant overcapacity and insufficient utilization. From an economic perspective, this structural asymmetry leads to a fragile business model in which profits in the high season are not sufficient to fully offset the fixed costs incurred in the low season.

The results highlight a fundamental dilemma for tourism regions: infrastructure must be dimensioned to ensure reliability and service quality during peak demand periods, but the same infrastructure can compromise annual profitability due to seasonal underutilization. The model therefore contributes to a more nuanced understanding of infrastructure planning in seasonal contexts and highlights the importance of incorporating demand modeling into economic assessments.

There are some limitations to consider. The model is based on scenario-based parameters, including assumptions regarding the proportion of electric vehicles, charging behavior, electricity procurement costs, and usage rates. Although these parameters are based on existing literature and current market data, deviations may occur in practice. Future research should validate and calibrate the model using empirical data from specific target locations, taking into account charging behavior patterns and dynamic pricing strategies. In addition, potential constraints of the local electricity grid infrastructure are not explicitly considered in the model and may influence the practical feasibility of large-scale infrastructure deployment.

Despite these limitations, the modeling framework provides a transferable analytical tool for destination managers and policymakers. It supports evidence-based decision-making regarding infrastructure sizing, seasonal planning, and long-term investment strategies. Given the increasing prevalence of electric mobility, such integrated approaches are becoming increasingly important to ensure both service reliability and economic resilience in regions dependent on tourism. The model can be easily adapted to other tourism regions by adjusting a limited set of input parameters.

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