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Electrifying Tourist Mobility in Bali, Indonesia: Setting the Target and Estimating the CO_2 Reduction Based on Stated Choice Experiment

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Abstract: The Bali Government has made the implementation of the electric vehicle (EV) policy a high priority considering its attractiveness for emission and air pollution reduction to maintain the sustainability of Bali's nature and tourism sector. Considering the uniqueness of the tourism sector in Bali and the mobility it generates, this study aims to investigate the factors that influence EV use by tourists based on several scenarios for estimating EV share target and the emission reduction contributed. For those purposes, the stated choice questionnaire was distributed online and offline to tourists in Bali and analyzed using the multinomial logit (MNL) model. While the study done during pandemic times, where the number of the tourist is significantly decreasing and the travel behavior influenced by mobility restriction imposed by the government, the data collection still covered mobility of both international and domestic tourist. The survey found that rental cost and accessibility, as well as the quality of charging stations are factors that affect EV use by tourists. Motorcycle parking cost was also found to influence EV use. These findings align with previous studies, and interventions such as fiscal incentives for rental companies and infrastructure development are suggested similar to EV incentives implemented in China, India, or the US. The development of the low emission zone (LEZ) is also proposed to manage parking fares similar to what was implemented in London, specifically to push the shift from internal combustion engine (ICE) to EV. Based on emission inventory calculation, 1.9 million kg of potential annual CO_2 can be prevented with the implementation of these policies by the government.

Keywords: electric vehicle; tourist; stated preference; multinomial logit model (MNL); CO_2 emission inventory

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1. Introduction

The sixth assessment report from the Intergovernmental Panel for Climate Change (IPCC) has raised concern that extreme and irreversible catastrophic results from climate change may come sooner than expected [1]. Therefore, this decade is critical for mobilizing full-fledged climate action to limit the global temperature rise to 1.5 degrees Celsius [2]. Given that land transportation is among the most prominent climate contributors [3,4], the electric mobility policy has been a popular choice for governments worldwide in past decades for decelerating CO_2 emission [5]. This is because the zero-emission vehicles policy potentially saves up to 30 percent of the total emission budget [6] of 45 $GtCO_2$ for the land transportation sector to keep the temperature rises below 1.5 degrees Celsius.

In the case of Indonesia, one of the promising markets [7], vehicle electrification has been recently developed and implemented. Jakarta and Bali are among the most progressive provincial governments in accelerating this policy. However, in contrast to Jakarta as the nation's capital, Bali has its own unique social, cultural and economic characteristics, which rely on the tourism sectors [8]. This uniqueness has given rise to complexities in developing the Electric Vehicle (EV) share target in Bali as a baseline and formulating recommendations for electric mobility implementation.

Bali is home to more than 700,000 people and attracts around six million tourists annually [9] through its nature, culture and burgeoning tourism. Economically, it heavily relies on tourist activities. Bali has suffered traffic congestion that deteriorates air quality due to the considerable amount of mobility generated by tourist activities and low public transport use [10]. With a substantial number of people opting for private mobility, the government has planned to extensively develop the EV ecosystem with the aim to attract its citizens and tourists to shift from internal combustion engine (ICE) to EV. To implement this plan, the Bali government has issued an underlying regulation for the development of a governance scheme and general action plan [11]. This regulation only covers the general aspects of development without clearly setting the EV share target and specific policies that are needed for implementation.

The stated choice experiment has been widely used for estimating market share in various disciplines due to its ability to simplify and summarize the choices made by individuals into a clear reflection of the behavior of a society [12]. The stated choice experiment has been used in many studies that aim to predict electric mobility market share or adoption [13–17]. However, the findings vary among geographical locations. For instance, while EV price adjustment has proven to be effective in Switzerland and Canada, people in the USA and China do not put too much emphasis on such financial attributes [16–19]. EV adoption has been associated with age groups. However, studies in China and Germany [19–21] show a different result from a study conducted by Musti and Kockelman [22] in the USA, which suggested that age positively influenced the possibility of someone adopting EV adoption. Moreover, most studies are conducted in developed countries [13,23], while less attention has been given to developing countries. Discrepancy in infrastructure quality and living standards as well as social and cultural differences mean that a separate study needs to be conducted in developing countries. Another factor to take into account is that several developing countries, such as Indonesia, have just begun to ramp up their infrastructure development in the last decade to increase their competitiveness [24].

Several studies have attempted to explore the potential market for EV in Indonesia, such as a Stated Choice Experiment by Prasetio et al. [25] in Bandung on electric public buses, and a study by Utami et al. [26] that explored EV adoption in eight provinces by incorporating attitudinal variables. Other studies have also been conducted to provide policy recommendations in preparation for EV adoption in several cities in Indonesia [27–30]. However, most of the analyses are made from the perspective of local commuters, while tourists, who stay for a limited time, are rarely taken into account.

Assessing the EV market share in Bali is essential for some reasons. First, Bali is known for its nature-based tourism. However, Bali has been facing numbers of environmental issues, including increases in air pollution [10]. Therefore, an EV master plan can facilitate actions to preserve air quality in the province and in turn support the sustainability of its tourism sector. Second, the Bali government has a vision for sustainable development across various sectors, including through the development of an EV ecosystem for sustainable mobility. While the underlying regulations for this have been issued, there has not been any policy assessment to set the EV market share target. Such assessment is vital to provide policymaker with recommendations for the development of action plans and targets to ensure that the investment poured into developing an EV ecosystem is used effectively.

The first objective of this study is to assess the EV adoption and choice behavior of tourists in Bali. The second objective is to estimate the potential CO_2 reduction and recommendations for EV policy implementation. Specifically, this study's novelty contributions are twofold. First, while several previous studies [13,16,31] have investigated the factors of EV adoption preference, this study aims to explore the preference from the side of tourists that are rarely investigated. Second, with the clear contributions of EVs to the environment, this study aims to assess the potential CO_2 reduction by integrating the result of EV adoption analysis. Moreover, with those analyses, this study also aims to provide knowledge on accelerate EV adoption specifically in areas that heavily rely on tourism such as Bali. For those objectives, the Stated Preference (SP) [32] questionnaire was distributed to tourists in mid 2021 in a combination of online and offline surveys due to the COVID-19 pandemic. This study used the multinomial logit (MNL) model [33] for investigating the factors that affect EV adoption in Bali. While previous studies are only explored the preference for EV using use discrete choice models [16,34,35], this study integrated the result of the MNL model into the CO_2 emission inventory methodology [4,31]. A review of current policies for the acceleration of EV implementation worldwide will be conducted alongside the choice experiment to be used as basis in formulating policy recommendations for Bali.

The remainder of the paper is structured as follows: the next section discusses the literature on EV policies in Bali and previous choice experiments in the context of EV; the third section describes the research method, data collection process and respondents' characteristics; the fourth section presents the estimation model followed by discussions and policy recommendations and the last part of the paper concludes the study.

2. Policy and Literature Review

2.1. Policy for Electric Vehicle Acceleration in Indonesia

To stimulate and promote Electric Vehicle (EV) adoption, the Indonesian government has stipulated Presidential Regulation No. 55/2019 regarding the Acceleration Program for Battery-Powered Electric Vehicles for Road Transportation. In addition to incentives, charging station facility, technical standardization and environmental protection, this regulatory instrument also covers the development of the domestic EV industry by aiming to build the capability to manufacture EVs locally, as well as to drive domestic research and development initiatives.

The Ministry of Industry has made the 2020s the decade of transition to EV and issued a 10-year strategy plan to develop domestic production capability for EV components through Ministry Regulation No. 27/2020 on Battery Electric Vehicle Industry Roadmap 2020–2030. Such strategy covers measuring the composition of locally produced EV components and developing domestic manufacturing, assembly and research and development capabilities. The Indonesian government has set the target to produce 80 percent of components domestically by 2030 for electric cars and by 2026 for electric motorcycles.

Following in the footstep of a number of countries that have mandated fiscal incentives for EV purchases, Indonesia has announced the exemption of plug-in hybrid electric vehicles (PHEV), battery electric vehicles (BEV) and fuel cell electric vehicles (FCEV) from luxury tax under Government Regulation No. 73/2019 on Goods Subjected to Luxury-Goods Sales Tax. This regulation also prescribes a new tax calculation mechanism in which the tax rate for a vehicle depends on its emission level. Considering that the near-term stimulus mainly focuses on enabling fully electric vehicles (BEV and FCEV), the government has been considering to exclude PHEV from the tax incentive. It should be noted that these incentives primarily take the form of package stimulus for EV manufacturers or sellers as they are responsible of withdrawing luxury tax. According to Minister of Internal Affairs Regulation No. 8/2020, the Ministry of Internal Affairs has set a vehicle tax and registration fee of up to 30 percent.

In relation to charging stations and battery swapping centers, the Ministry of Energy and Mineral Resources has issued Ministerial Regulation No. 13/2020 on BEV Charging Station Infrastructure. The regulation prescribes that EV battery charging and swapping companies in Indonesia must provide services in at least two different provinces in Indonesia. Currently, manufacturing, supply and sales in the battery charging and swapping market are exclusively handled by national utility providers. Thus, to acquire a business permit for battery charging and swapping business in Indonesia, companies must collaborate with a national utility provider. As national utility providers have begun offering public and home battery charging and battery swapping services, incentives and subsidies for electricity and power installation are under consideration to stimulate EV adoption.

As the first province in Indonesia to enact a sub-regional EV policy through Governor Regulation No. 48/2019 on EV Use, Bali has started to expand its focus to the preservation of cultural heritage sites and the environment. This has been implemented by promoting efficient energy sources, phasing out transportation-related air pollution and boosting EV infrastructure installation in Bali. Under the supervision of Bali's Transportation Agency, government institutions and state-owned enterprises operating in Bali are required to install an EV charging facility in their property. In addition, the regulation aims to phase out ICE vehicles in Bali by gradually increasing EV adoption through fiscal and non-fiscal incentives. Fiscal incentives a include annual vehicle tax and registration fee exemption, while non-fiscal incentives include the right to reduce parking fares, exclusive road access and other infrastructure development incentives. Bali's sub-regional programs and strategic plan will be complemented by the action plan that is currently being developed.

2.2. Choice Experiment in the Electric Vehicle Context

In terms of electric mobility, numbers of studies worldwide has put interest on how different scenarios of vehicle electrification can positively contributes to environment and energy efficiency (e.g., [36,37]). Moreover, some studies are also interested in investigating the demand side or the behavior of the users. Liao et al. [13] and Rezvani et al. [23] have reviewed more than 40 empirical studies on EV published in the last few decades worldwide. Most of these studies use the choice experiment to identify the factors that significantly influence EV adoption. It should be noted that these studies are conducted on drivers and potential car buyers in different countries and thus, they mainly focus on purchase for ownership and mainly ignore other vehicle usage and acquisition options such as car-sharing, ride-hailing, public transportation and rental. Meanwhile, the different factors that consumers take into account in EV adoption can be categorized into financial, technical, infrastructure and policy.

In terms of financial attributes, apart from the purchase price, operational cost is found to have a significant effect on EV adoption. Operational cost is measured differently in various studies. Musti and Kockelman [22] defines operational cost as cost per 100 km, Mabit and Fosgerau [38] defines operational cost as the combination of energy cost or fuel-saving cost and Hess et al. [16] includes routine maintenance cost while excluding energy cost in the operational cost. As expected, a considerable amount of these studies [14,34–37] suggest that the lower operational cost for EV compared to conventional vehicles is a key factor that drives EV adoption.

Interestingly, some studies [39–43] discussed different findings regarding the technical features of EV (e.g., driving range, charging time, maximum speed), in which these features serve as both a contributing factor and a barrier to EV adoption by potential consumers. Specifically, there is a huge variation in the technical features offered by EV across different technologies. For instance, the relatively shorter driving range of EV compared to conventional cars is one of the biggest barriers to EV adoption [13]. On the contrary, some of the technical features offered by EV such as low noise and smoothness attract consumers [43]. In previous studies, recharging time has been cited as a factor that needs to be further assess. It takes eight hours to fully charge an electric car with a common at-home charger, while charging the battery of that same car with a fast charger would take 15–30 min. This charging time has been found to be a significant factor that influences consumers' decision to adopt EV in a number of studies [31,34,44,45]. Unfortunately, not many studies actually assess the effect of charging times on customers' preferences.

The technical features of EV are found to be associated with infrastructure availability. For instance, charging station density significantly influences how potential consumers perceive driving range [46]. Moreover, this attribute is commonly assessed by evaluating the availability of charging stations around different key locations such as homes, shopping malls, etc. Lastly, policy instruments that focus on price reduction have been found to be both effective and ineffective in encouraging EV adoption. For instance, while others suggest to the contrary [16,39], some studies [40,44] conclude that priority lane access is perceived as a favorable policy by consumers.

Outside of the attributes mentioned above, other key variables such as car condition, place of residence, personal experience and social influence are rarely included in the choice attributes. They have been found to be influential attributes, yet only studied by limited number of scholars [36,45,46]. This is understandable as the amount of attributes included would affect the complexity of the study [13]. Thus, it is crucial for researchers to compile a list of potential attributes to assess the resulting conclusion more accurately.

3. Methodology

3.1. Multinomial Logit Model

In the current study, the choice experiment is designed based on theoretical mode choices and their determinants. This research uses the MNL to draw a conclusion on the relationship between the determinants and the choices as suggested by earlier studies [30,47–50]. Below is the standard form of the MNL model [33]:

$$P_{r(i)} = \frac{expU_i}{\sum_j^i U_j} \tag{1}$$

where:

P_{ri} = the probability of the individual choosing alternative i,
U_j = the systematic component of the utility of alternative j.

The mode choice and vehicle adoption models are associated with the characteristics of the individuals and the characteristics of the modes/vehicles. Therefore, in choosing a mode/vehicle, an individual seeks to maximize the utility associated with them and their characteristics. Such utility (a) relates to individuals' characteristics e.g., gender, income and age, (b) relates to the alternative(s) and (c) relates to the interaction between the attributes of the alternatives and the characteristics of the individuals [33]. Let the total utility be the sum of the utility components.

$$U_i = U_{Sq} + U_{Xi} + U_{St,Xi} \ + \varepsilon_i \tag{2}$$

where:

U_i: The systematic portion of utility of alternative i for individual q,
U_{Sq}: The portion of utility associated with characteristics of individual q,
U_{Xi}: The portion of utility of alternative i associated with the attributes of alternative i,
$U_{Sq,Xi}$: The portion of the utility that results from interactions between the attributes of alternative i and the characteristics of individual q.
ε: Error term represents variables that are not captured in the analysis.

Moreover, there are limitations in determining the coefficient for the alternative utility function. Therefore, to make measuring the utility function easier, the study uses a reference category as the single constraint for each set of parameters to zero and reinterpret the remaining components to show the differences between the reference alternative and other alternatives as suggested by Koppelman and Bhat [33]. The maximum likelihood estimation (MLE) method is used to determine all coefficients for the utility function in the MNL model equation.

3.2. Stated Preference Questionnaire for Choice Experiment

The stated preference approach is used to assess the respondents' EV decision. Variables that influence the decision were carefully selected for the study based on literature review [5,13], then several adjustments were made for the context of Indonesia and tourism. As the mode choice approach is used for the tourist experiment, the choices are given based on the available modes of transportation for tourists in Bali. As shown in Table 1, considering the local context, respondents can choose from five modes of transportation: urban bus services (Trans Metro Dewata/TMD), rental ICE and EV cars and rental ICE and EV motorcycles. The study also covered motorcycle-based ride-hailing.

Table 1. Attributes and levels in the choice experiment for tourism respondents.

Attributes	TMD *	RC ICE	RC EV	MC ICE	MC EV	MBRS	CBRS
Electric based [c]	0/1					0/1	0/1
Rental cost (000 IDR)		300/400/500	300/400/500	50/100/150	50/100/150		
Daily operational cost (000 IDR)	18/36/48	20/50/100	15/20/50	5/10/40	5/10/20	40/60/80	100/150/200
Daily access cost [a] (000 IDR)	10/15/20						
Parking cost (000 IDR)		10/15/20	0/10/15	2/5/7.5	0/2/5		
Travel time per trip [b] (minutes)	30/45/60	25/35/45	25/35/45	15/20/25	15/20/25	15/20/25	25/35/45
Access time per trip [a] (minutes)	0/10/20						
Waiting time per trip (minutes)	5/10/15					5/10/15	5/10/15
Speed of charging (kWh)			22/75		22/75		
CO_2 Emission (kg)	2/4/5	10/12/15	7/10	5/6/7	3/5	5/6/7	10/12/15
Distance to charging station (km)			2/4		2/4		

* TMD = trans metro Dewata; RC ICE = rental car ICE; RC EV = rental car EV; MC ICE = motorcycle ICE; MC EV = motorcycle EV; MBRS = motorcycle-based ride-sourcing; CBRS = car-based ride-sourcing; [a] access refers to the trip taken to access the TMD shelter; [b] average trip distance = 10 km based on preliminary survey; [c] 1 = yes; 0 = no.

(MBRS) and car-based ride sourcing (CBRS) of which users have grown in the last decade across Indonesian [51] cities, including Bali. The attributes consist of 12 variables selected based on the literature review (e.g., operating cost, parking cost, etc.) [13] with a view adjustments for the context of tourist mobility (e.g., rental cost).

Based on the attributes and their levels, 36 experimental design scenarios were developed using the software NGENE [52] with Defficient design for each of the surveys (i.e., tourists and local commuters). To prevent the respondents from getting overwhelmed by too many SP scenarios, six different questionnaires were made for six different situations.

3.3. Data Collection

The final questionnaire consists of three sections (described in the Supplementary Materials). The first section explores the travelers' personal characteristics such as income, occupation, age and gender. In the second part of the questionnaire, the respondents are asked about their travel habits such as distance, main transportation mode and transportation cost. The last part contains questions on the EV mode choice, which was developed based on stated preference. The questionnaire was available in Indonesian and English to make it more accessible by international tourists.

The questionnaire was administered in a two-wave survey. The first wave was conducted offline, while the second wave was conducted online due to the mobility restriction imposed by the government in early July 2021. The offline survey was conducted in various tourist locations in Bali. In contrast, the online survey was distributed through social media and with the help of the local tourism authority. While the offline survey is preferable, especially for data collection, with the high information and communication technology (ICT) penetration and use in Indonesia, there was no significant issue in the data collection phase of the online survey, especially considering the increased online activity during this pandemic [53]. Data collection began on 12 June 2021 and was completed on 6 July 2021. After a series of reviews for completeness, 951 data sets were used in the analysis out of the total 1171 data sets. The respondents' general characteristics is shown in Table 2.

The analysis is based on the sample of Bali tourists over 17 years of age. Around 70 percent of the tourists were below 35 years old, and most of them were male working in the private sector. Moreover, a large share of respondents (25 percent) has an income of over IDR15 million (USD1034) per month. At 69 percent, most of the respondents were domestic tourists.

Table 2. General characteristics of respondents (n = 951).

Variable	Characteristic	Relative Frequency
Age	18–25 years old	32%
	26–35 years old	37%
	36–45 years old	17%
	46–60 years old	3%
	>60 years old	0%
Gender	Male	63%
	Female	36%
	Rather not say	1%
Income per month [a]	<3 million IDR (USD206)	12%
	3–5 million IDR (USD206–344)	16%
	5–7 million IDR (USD344–482)	23%
	7–10 million IDR (USD482–689)	13%
	10–15 million IDR (USD689–1034)	12%
	>15 million IDR (USD1034)	25%
Occupation	Civil servant	3%
	Employed in the private sector	37%
	Lecturer/teacher	6%
	Student	10%
	Health worker	1%
	Housewife	3%
	Entrepreneur/self-employed	25%
	Freelancer	10%
	Unemployed/retired	3%
Nationality	Indonesian	69%
	Non-Indonesian	31%

[a] US$1 = IDR 14,505 in July 2021.

4. Results

4.1. Tourism Activity

Data on the characteristics of tourist visits in Bali covered the number of the respondents' visits in the last two years, travel characteristics in Bali, accommodation and destination locations in Bali. First, the characteristics of the respondents' recreational stay in Bali are presented in Table 3. It should be noted that this data set is collected during a holiday season in Indonesia amid the COVID-19 pandemic, in which several pandemic-related measures were put in place. Since early 2021, the Indonesian government has been promoting the unprecedented 'Work from Bali' (WFB) program, which encourages employees to stay in Bali to boost Bali's economy amid the dramatic decline of international tourists [52–54]. According to a local newspaper, the number of private motorcycles and cars of domestic tourists entering Bali increased by approximately 845 percent and 228 percent respectively from the same period in the previous year [55]. This may explain the high shares of private car and motorcycles in this data set, which may not be the case after the pandemic.

Most tourists come to Bali once or twice in the last two years with less than three travel companions, according to reports. On the question on main transportation modes, an overwhelming number of tourists answered private and rented cars as their main transportation mode. Meanwhile, the second most popular main transportation modes among tourists are private and rental motorcycles. Furthermore, almost 40 percent of tourists travel 10–20 km per day and roughly one-third of respondents travel more than 20 km per day.

Table 3. Travel and tourism activities of respondents.

Variable	Characteristic	Relative Frequency
Number of visit(s) in the last two years	One time	36%
	Two times	27%
	Three times	17%
	>3 times	14%
Travel companion(s)	none	13%
	One person	20%
	Two persons	29%
	Three persons	14%
	>3 persons	19%
Main transportation mode	Bus	4%
	Online taxi	5%
	Online motorcycle taxi	6%
	Car rental	28%
	Motorcycle rental	40%
	Private car	22%
	Private motorcycle	13%
Average trip distance per day [a]	<2 km	2%
	5–10 km	27%
	10–20 km	36%
	20–30 km	20%
	>30 km	14%
Vehicle rental cost per day [a]	none	32%
	<IDR50,000 (USD3.45)	7%
	IDR50,000–100,000 (USD3.45–6.89)	23%
	IDR100,001–200,000 (USD6.89–13.78)	21%
	IDR200,001–400,000 (USD13.78–27.57)	10%
	>IDR400,000 (USD27.57)	5%
Fuel cost per day [a]	none	11%
	<IDR20,000 (USD1.37)	10%
	IDR20,000–40,000 (USD1.37–2.76)	30%
	IDR40,001–60,000 (USD2.76–4.13)	13%
	IDR60,001–80,000 (USD4.13–5.51)	12%
	>IDR80,000 (USD5.51)	24%
Additional travel cost per day [a,b]	none	18%
	<IDR20,000 (USD1.37)	52%
	IDR20,000–40,000 (USD1.37–2.76)	22%
	>IDR40,000 (USD2.76)	3%

[a] US$1 = IDR14,505 in July 2021; [b] parking and toll cost.

The survey also captured the travel-related cost for a recreational stay in Bali. Around two-thirds of respondents spend their money on vehicle rental. Moreover, one-third of those who rent or use their private vehicle reported to spend IDR20,000–40,000 (USD1.37–2.76) per day for fuel. Furthermore, most tourists reported spending additional travel-related costs (e.g., parking fares, toll) of less than IDR20,000 (USD1.37) per day. Although 15 percent of tourists do not use private and rental vehicles, which require fuel, as their main mode of transport, less than 11 percent of tourists reported zero spending on fuel cost. This may indicate that tourists using public transportation and ride-hailing passengers still use private or rental vehicles as an alternative transportation mode to complement their main transportation mode.

4.2. Mode Choice Model for Tourists

The result of the MNL model for tourist's mode choice is presented in Table 4. Biogeme [56] is used to estimate all of the parameter coefficients in the MNL model. The model used rental EV car as the reference category or the basis of the measurement. Before reviewing the estimation result, the goodness of the model is evaluated. The log-likelihood of the model with the intercept (LL(0)) is −11,104.36, while the final model's log-likelihood (LL(β)) is −9611.81. The significant difference between the values of LL(0) and LL(β) means that the variables improve the model significantly, which implies that the final model is meaningful. The rho^2 value is 0.134, which is relatively low. However, given various significant variables, the model is arguably good for interpretation.

Table 4. Mode choice model for tourists.

Variable	Parameter Estimate	T-Stat
Alternative specific constant (ASC)		
ASC TMD	−0.864	−2.560 **
ASC Car ICE	−0.932	−2.770 **
ASC MC ICE	−1.06	−3.500 **
ASC MC EV	0.638	2.510 **
ASC MBRS	−2.42	−5.880 **
ASC CBRS	−4.18	−6.220 **
Variables		
Access cost	−0.008	−0.802
Access time	0.001	0.234
Charging speed	0.001	2.730 **
Electric base	0.091	1.21
Emission	0.001	0.083
Distance to charging station	−0.063	−2.860 **
Operational cost	0.001	0.825
Parking cost of rental EV car	0.006	1.14
Parking cost of rental ICE car	0.008	0.716
Parking cost of rental EV MC	−0.075	−5.280 **
Parking cost of rental ICE MC	−0.047	−2.880 **
Rental cost	−0.001	−1.990 **
Travel time of MBRS	0.011	0.681
Travel time of rental EV car	−0.002	−0.459
Travel time of rental ICE car	0.002	0.426
Travel time of rental EV MC	−0.021	−2.870 **
Travel time of rental ICE MC	0.021	2.210 **
Travel time of CBRS	0.016	0.923
Travel time of TMD	0.002	0.757
Waiting time	0.009	1.11
Rho^2	0.134	
LL(0); LL(β)	−11,104.36; −9611.81	

Reference category: rental EV Car; ** = significant at 5%; TMD = trans metro Dewata; MBRS = motorcycle-based ride-sourcing; CBRS = car-based ride-sourcing.

As the rental EV car is the reference category, the evaluation of the constant (if everything else is equal) of the models showed that the rental EV car is the superior mode over other modes except for the rental EV motorcycle. It appears that rental EV vehicles (i.e., car and motorcycle) show positive preference for use. Moreover, several variables are shown to have significant influence on the mode choice. The interpretation of variables that significant is based on the positive/negative sign of the coefficient, with positive sign imply that the increase of the variables will increase the probability of the alternatives chosen. The significant rental cost is a negative sign implying that the increase of rental cost will decrease the probability of that mode being used. The findings suggest that the cost associated with acquiring the vehicle, whether permanent or semi-permanent (rent), is important for users and this echoes the study of Glerum et al. [17] and Hess et al. [16]. It is important to consider the car rental cost in the formulation of the EV rental cost, given that the rental costs for ICE motorcycles and cars in Bali are around IDR50 thousand and IDR450 thousand, respectively.

Electricity need is a risk that influences EV choice, with the distance to charging location and speed of charging being among the significant variables This confirms the

Rasouli and Timmermans [34] study that investigates EV use among local commuters in the Netherlands. Therefore, in general, all potential users, whether permanent or semi-permanent commuters, might feel safer when they can easily charge in various locations. Moreover, as tourist activities are spread across various locations during the day to maximize holiday time, less charging time will also benefit them. Less charging time was also found significant in earlier studies from the local commuters' perspective in the Netherlands [31] or United States (US) [45].

Moreover, parking cost is also a factor that has been found to influence ICE and EV motorcycle vehicles. The different contexts for a motorcycle and a car might be the reason for discrepancies with the findings in the Netherlands [31] and the US [16]. Based on this finding, managing parking fares for motorcycles might be the right policy to push for EV motorcycle use by limiting the ICE motorcycle use. Moreover, higher travel time was also found to negatively influence the adoption of EV vehicles, but does not lower the use of ICE motorcycles. It implies that ensuring adequate travel time or improving the driving technology (specifically for speed) for EV motorcycles might increase EV use in the future.

4.3. Estimation for the CO_2 Emission Reduction

With the objective of decreasing GHG emission through EV policy, the CO_2 emission reduction is calculated for Bali's tourist mobility. This study uses IPCC's GHG inventory calculation method [35], taking into account the local context for emission factors [4]. The basic concept of the CO_2 emission calculation is to calculate the net emission of doing nothing in which no EV vehicle is used and doing something in which EV is used for mobility. The concept can be presented as follows:

$$R - CO_2 = \sum DN - TCO_2 - \sum DS - TCO_2 \quad (3)$$

With $R - CO_2$ is the net reduction of CO_2, $DN - TCO_2$ is the total CO_2 emission without the project and $DS - TCO_2$ is total CO_2 emission with the project. The CO_2 emission is calculated using IPCC's [35] methodology with practical adaptation to the case of rental vehicle electrification, as follows:

$$Total\ CO_2\ emissions\ (TCO_2)\ per\ year = \frac{D_j}{FCF_j} \times EFs_{k/w} \times TV_j \times 300 \quad (4)$$

where j is the type of vehicle (e.g., motorcycle or car); D_j is the average distance (kilometers) per day for j-vehicle; FCF_j is the energy economics factor for j-vehicle in kilometer per energy (i.e., liter or kilowatt-hour); EF_{sk} is the emission factor based on the type of fuel (k) or power plant/grid (w) in kilogram-emission per energy (i.e., liter or kilowatt-hour); TV_j is the total number of j-vehicles and 300 is the factor used in calculating yearly CO_2 emission during the tourist season.

The CO_2 emission reduction calculation is based on how many ICE vehicles are replaced with EV vehicles. Several scenarios were developed and the MNL model is used to calculate the percentage (%) of mode shift from ICE to EV for each of the scenarios. Several assumptions were made in the EV share calculation considering that the MNL model consisted of various variables. Assumptions were made on ICE rental cost (i.e., car and motorcycle). Other assumptions were 500 m distance to charging station and 22 kWh charging speed. In estimating the market share for each type of vehicle (car and motorcycle), the calculation is being normalized (normalized value from the MNL model for estimating market based on type of vehicle (e.g., car or motorcycle) is calculated through: $\%\ EV\ share_{norm-i} = \frac{\%\ EV - i_{MNL}}{\%\ EV + ICE - i_{MNL}} \times 100\%$ where i is the type of vehicle (e.g., car or motorcycle); $\%\ EV_{MNL}$ is $\%EV\ share$ generated by the MNL model simulation and $\%EV + ICE_{MNL}$ is the total $\%EV + ICE\ share$ generated by the MNL model simulation). The scenario and result of mode shift are described in Table 5.

Table 5. Scenario and result of normalized rental EV share.

No.	Scenario	Share of Rental Vehicle (%) [a]			
		EV Car	ICE Car	EV Motorcycle	ICE Motorcycle
1	Similar EV and ICE rental costs	70.73	29.27	80.35	19.65
2	EV rental cost 1.25 × ICE rental cost	68.35	31.65	80.15	19.85
3	EV rental cost 1.50 × ICE rental cost	65.87	34.14	79.96	20.04

[a] Rental ICE Car = IDR450,000; rental ICE Motorcycle = IDR50,000; 500 m distance to charging station and 22 kWh charging speed.

The first scenario, in which the EV and ICE rental costs are similar, shows the highest EV market compared to other scenarios with EV cars making up 70.73 percent of the total rental cars and EV motorcycles making up 80.35 percent of the total rental motorcycles. The increase of EV rental cost to almost twice the ICE rental cost (third scenario) affects electric cars more than motorcycles, although the decrease is relatively low given the low sensitivity of rental cost as found through the MNL model calculation.

This study also collects data from rental companies association in Bali to capture the total number of rental vehicles (TV_j). An interview was conducted with the rental vehicle association in Bali to collect data on the total number of rental vehicles due to the limited data available from the local transportation department. The rental companies association estimated that a total of 3300 cars and 1100 motorcycles are used for rental. They also underlined that the number might be higher in reality given that there are so many unofficial traditional rental companies, especially for motorcycles, in Bali. Moreover, they also said that of the total available rental vehicles, 98 percent are rented, while 2 percent are unbooked. In addition, The average distance used in the study is based on the questionnaire explained in the previous section, the emission and fuel consumption factors under the local context from Rizki et al. [4] as well as the Electric Vehicle Database [57]. Based on the above factors and data, the total emission saved is described in Table 6.

Table 6. Estimation of emission savings.

Scenario	Total Rental Vehicle [a]	% Shift	Type of Vehicle	Average Travel Distance (km/Day) [b]	Net Savings/Year [c] (Ton CO_2)	Total Net Savings (Ton CO_2)
1	3300	70.73	Car	19.9	1742	1945
	1100	80.35	Motorcycle	16.5	203	
2	3300	68.35	Car	19.9	1683	1885
	1100	80.15	Motorcycle	16.5	202	
3	3300	66.87	Car	19.9	1646	1848
	1100	79.96	Motorcycle	16.5	202	

[a] Based on an interview with the rental companies association in Bali Province in 2021; [b] data from the questionnaire; [c] total days a year is assumed at 300 days in consideration of the tourist seasons.

The result shows that the best scenario is the first scenario where significant incentive is given by the government to maintain a similar rental cost between EV and ICE. The potential reduction from the EV acceleration program for tourists is 1.9 million kg CO_2. It should also be noted that car more significantly reduces CO_2 emission given that emission from cars is higher than that from motorcycles. A pessimistic estimation of the rate of motorcycle rental however shows a lower number. Moreover, the current calculation of the amount of emission that can be saved is based on the existing electrical power plants. If intervention is made for renewable energy supply, the emission reduction will be higher.

5. Discussion on Policy Recommendations

Various cities worldwide have implemented electric mobility with the support of various studies in the preparation of the right policies, including on infrastructure development and demand management [58]. Given the Bali Government's commitment to electrifying mobility in Bali, this study attempts to provide several recommendations.

In this study, fiscal incentive was indicated as one of the important factors that drives EV use, following the pattern of other countries, both developing and developed [5,13,56]. Considering the focus on the mobility and reliance on rental vehicles for mobility, the rental companies might be the best target for the fiscal incentives. Lower lease interest, such as the one implemented in China [59] and India [60], might be critical and might increase the competitiveness of EV compared to ICE vehicles. While the gap between EV and ICE purchase costs is getting narrow, driven by the technological advancement of batteries [57], subsidy for EV purchase can be critical in the short term. Countries such as the US [14,56], India [60], Norway [61] or China [59,62] have been experiencing a surge in EV use after implementing this policy. With the current EV tax subsidy scheme in Indonesia, there is room for a more aggressive limited-time subsidy to be closely reviewed and assessed in consideration of any decrease in EV vehicle cost. Technological advancement and strengthening of the domestic supply chain and industry are parts of the strategy implemented by China [57,60] and the US [5] to reduce EV prices. Indonesia has a promising EV market [7] and great potential for the development of the EV industry [63]. EV prices may be reduced if the government's intervention is focused on accelerating the development of the domestic EV industry ecosystem given its natural resources.

Accessibility and the quality of charging infrastructure were also identified as variables that influence the decision to adopt EV. Previous studies have also underlined distance capacity as one of the EV barriers considering that users have to charge during their daily activities [42,62,64]. Therefore, some countries have implemented various incentives for the development of this infrastructure. India provides capital subsidy and concessional land for private companies developing charging stations [60]. The US also gives users incentives to install a home charger [65]. In terms of technological advancement, most countries also provide incentives for research and development of fast-charging infrastructure [5] and renewable energy-based charging stations [60]. In Indonesia, a mechanism has been established for the government and the private sector, with the state-owned Indonesian Electricity Company (PLN) being among the forerunners for developing charging stations. The acceleration of such development might be possible with cooperation between charging station providers, local tourism private sector and tourism regulators. As a tourism regulator, the Bali government has an important role in leveraging this cooperation. Additional incentives for tourism areas that make a renewable energy-based fast-charging station available might be relevant, as found in other countries.

In line with the study by Chorus et al. [31] and Hess et al. [16], we found that parking fares have no significant influence on car use (i.e., EV and ICE). Meanwhile, interestingly, parking fares negatively influence motorcycle use, which indicates that parking fares management is a potential policy for motorcycle users. Transportation Demand Management (TDM) [66] has underlined the importance of parking management in pushing people to shift from private transportation to more sustainable transportation modes. Therefore, managing parking fares for EV and ICE motorcycles might improve tourists' EV share. While parking fares management is needed for both EV and ICE, Jakarta began implementing the free parking incentive for EV in 2020, while the incentive for ICE parking is still being discussed by the government [67]. The Newham Government in London, UK [68] manages parking permits based on vehicle emission, a policy that is integrated with various emission-related policies under the London Ultra Low Emission Zone (ULEZ). Under this policy, London's emission from vehicles has seen a significant reduction (65 percent) [69]. Parking fares management has the potential to be implemented in Bali, especially in sustainability and nature-based tourism areas. Looking at the regulations that have been issued by the government, several Low Emission Zone (LEZ) or EV zones are expected to be developed in Bali. In this light, a shift to emission-based parking fare is critical.

This study also indicated that the implementation of EV policy for tourist mobility could reduce CO_2 emissions. Support from the government for rental companies to maintain rental cost and for the provision of accessible charging stations will potentially cut 1.9 million kg of CO_2 annually. This number is equal to 32,668 tree seedlings grown in the span of ten years or avoided emission from 84,065 trash bags of waste from recycling instead of disposal to landfill (Based on EPA CO_2 equivalencies calculator [70]). The annual emission reduction that can be achieved from the adoption of EV for tourist mobility depends on government intervention. The most critical is intervention in fares and charging stations. Moreover, given that the amount of emission from electricity depends on the emission produced by the power plants, this study proposes that the Government facilitates and supports the plan of PLN and other private sector actors [71] to develop renewable energy-based power plants. An alternative source of EV electricity supply is solar-powered charging stations [72], which have been introduced by local private sector actors [73].

6. Conclusions

This research has laid out the results of the investigation on the factors that influence EV adoption by tourists in Bali and the potential emission reduction contributed by the policy. The findings of this study are threefold. First, rental cost incentive is key to improve the attractiveness of EV for tourists, while operational cost is not a significant factor. Second, charging stations accessibility and quality positively influence EV use. Last, the research also found that parking tariffs also have significant effect on decreasing motorcycle use.

Moreover, this research found that the implementation of EV policy in Bali will potentially reduce up to 1.9 million kg of CO_2, which will contribute to maintaining the sustainability of Bali's tourism sector. These findings show that cooperation between the national and local governments and the private sector is needed not only in the development of EV infrastructure (i.e., charging stations, renewable energy power plan, etc.), but also in the development of fiscal incentives (i.e., tax exemption, subsidy, lower interest, etc.). Similar with what was implemented in China [59] and India [60], improvement of fiscal incentives needs to be accelerated to increase the competitiveness of EV. These fiscal incentives can be implemented for a short term for rental companies in Bali as more technological advancements and EV industry development in Indonesia will hopefully decrease EV cost in the long run. Furthermore, the parking fares management for ICE and EV motorcycles is proposed to be integrated with the planning for EV or LEZ as successfully implemented in London [69]. While the studies in terms of EV adoption from a tourist perspective are rarely to be investigated, some findings, in terms of parking cost and charging quality [13], are similar to earlier studies of EV in commuters context. However, this study also found no significant relationship of operational cost to the choice of EV, which is different from previous studies in developed countries [22]. Therefore, this underlines the different behavior between developing and developed countries in terms of EV adoption.

While this research provides several important findings, we have also laid out the limitations of this study. With the data collection conducted during pandemic times, where the number of tourists significantly decreased, and their travel behavior is affected by the mobility restriction and health protocol imposed by the local and national government, this study can be a basis for capturing tourist travel behavior during the pandemic. However, while previous studies [53,74] have underlined the effect of the pandemic on future travel behavior, further works of travel behavior of tourists post COVID-19 should be taken. Moreover, the tourists' travel data for this research was captured daily. Considering the discrepancy between the mobility of daily commuters and tourists, a more detailed travel diary is important in capturing tourism data in future studies. Several studies [75,76] have also underlined the importance of reviewing mobility pattern to identify key locations for public charging stations. Considering the unique pattern of tourist mobility, which occurs in limited time and are spread across different locations, further studies are needed to identify strategic locations for charging stations. This study also does not consider several multi-dimensional factors (i.e., attitude, social norms, etc.) to predict the tourists' inclination to use EV. Further works that accommodate these variables will give more insight into EV use in Bali, which could help formulate a more comprehensive sustainable transportation policy in Bali.

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