International Journal of Grey Systems
ISSN 2767-6412 / eISSN 2767-3308
2022 Volume 2 Issue 1: 38–56
https://doi.org/10.52812/ijgs.46

Evaluation of Barriers to Electric Vehicle Adoption in Indonesia through Grey Ordinal Priority Approach

Cliford Septian Candra[1,*]

[1] *Binjiang College of Nanjing University of Information Science and Technology, Wuxi, China*

*Corresponding author: *clifordseptianc@gmail.com*

Received 23 April 2022; *Revised* 28 July 2022; *Accepted* 29 July 2022

Abstract: Emissions from vehicles are a major contributor to greenhouse gases, and thus climate change. Electric vehicles (EVs) provide a promising solution to deal with this problem. Even though in the emerging economies like China and Europe, the adoption of EVs is praiseworthy, the pace of the EV rollout in Indonesia is slow. The Indonesian electric vehicle market has remained stagnant due to the country's low adoption rate of electric vehicles, which is currently less than 0.3%. This is because electric vehicle adoption has been stymied in Indonesia for a variety of reasons. As such, the purpose of this study is to determine the factors influencing electric vehicle adoption in Indonesia and to rank the barriers to widespread EV rollout in the country using the Grey Ordinal Priority Approach (OPA-G). It is found that high initial purchase price, insufficient amount of charging infrastructure, and a lack of government incentives are key barriers to the EV adoption in Indonesia.

Keywords: Electric Vehicle; Barriers; Grey Ordinal Priority Approach; Multiple Criteria Decision Analysis; Indonesia

1. Introduction

Transportation is an essential component of contemporary civilization; it is necessary for economic development, provision of a living wage for the masses, and the creation of various micro and macroeconomic benefits (Krishna, 2021); however, the transportation sector is also one of the largest and fastest-growing carbon dioxide emitters, accounting for 16.2 percent of total global carbon dioxide (CO2) emissions in 2020 (Ritchie, 2020), which hurt the environment and human health (Degirmenci & Breitner, 2017). Countries sought a solution to reduce carbon emissions produced in this sector, and Khalili *et al.*, (2019) found that alternative energy sources have the potential to replace fossil fuels which currently provide energy for almost 92 percent of transportation fleets/vehicles. To reduce reliance on fossil fuel energy, electric vehicles (EVs) offer a promising opportunity for countries to replace their transportation sector, which is primarily powered by fossil fuel energy, with more environmentally friendly alternative energy (electricity).

An electric vehicle (EV) is a vehicle that is propelled by one or more traction motors or electric motors, with electrical energy stored in batteries or other energy storage (Rudatyo & Tresya, 2021). Electric vehicles have the potential to become a viable solution to the growing environmental, economic, and energy concerns in transportation such as air quality, climate change, and growing urbanization (Haddadian *et al.*, 2015) because they emit fewer greenhouse gases and pollutants into the atmosphere than gasoline or diesel vehicles do (Ehrenberger *et al.*, 2019). However, in a world where developed countries like the USA have faced setbacks in the adoption of the EV (Bakker, 2021), the challenges that the developing countries (excluding China) are facing are no small. Currently, more than 94% of the vehicles in Indonesia, a major developing country in East Asia, are fossil-fuel vehicles (PWYP, 2019) while EVs account for only 0.2% of them (Grupta & Hansmann, 2021).

According to the World Population Review (2022), Indonesia is in the 11th position as the largest emitter of greenhouse gases by contributing around 2.09% of total greenhouse gas emissions. To address this issue, Indonesia intends to transition from internal combustion engines to more environmentally friendly electric vehicles, a long-term goal that is supported by actions such as the issuance of Presidential Regulation No. 55 of 2019, which includes an incentive to encourage the transition process. Replacing ICEVs with EVs is also underway in several cities, most notably Jakarta, Indonesia's capital, which is routinely included on lists of cities with poor air quality, even ranking among the top 6 cities with the worst air quality in 2019 (IQAir, 2022).

Indonesia is one of the largest emitters of greenhouse gases, one of the primary causes of climate change; as Southeast Asia's largest economy and second-largest car manufacturing nation, Indonesia is attempting to switch the transportation sector away from fossil fuel-powered vehicles and toward more environmentally friendly electric vehicles; however, the challenges Indonesia faces are significant, making adoption of electric vehicles in Indonesia extremely slow. Numerous studies have identified barriers to the adoption of electric vehicles in Indonesia, but few have identified and prioritized the predominant barriers to the adoption of electric vehicles in Indonesia. The current study will fill this gap in the literature by identifying the drivers and barriers to electric vehicle adoption in Indonesia followed by the weighting of these drivers and barriers based on the opinions of the respondents. The current study recognizes the following research questions:

(1) What is the current status of the electric vehicle (EV) industry in Indonesia?
(2) Which are the most significant barriers (and drivers) to EV adoption in Indonesia?
(3) How Indonesia can overcome challenges and improve EV adoption?

This is the first study where the OPA-G is being employed for the evaluation of barriers to electric vehicle adoption. The rest of the study is organized as: The second section reviews the past literature on the EV and the status of its current popularity in Indonesia. The third section presents the model. The fourth section presents the research methodology. The fifth section presents data analysis and discussion. In the last section conclusion and recommendations are reported.

2. Literature review

2.1 Overview of electric vehicle industry in developed countries

Electric Vehicle development is accelerating; after a decade of rapid growth, there are now over 16 million electric vehicles (EVs) on the road worldwide (Lambert, 2022) of which 90 percent of EVs are concentrated in China, Europe, and the United States (IEA, 2020). Several countries, particularly developed countries, have made significant strides toward mass EV adoption. According to Fortuna (2019), the top 15 countries with the highest EVs uptake in terms of market share are all European countries, with Norway leading the pack with 82.7 percent market share in the first half of 2021, followed by Iceland (55.6%), Sweden (39.9%), Finland (28.3%), Denmark (26.8%), Germany (22.1%), Netherlands (19.7%), Luxembourg (18.3%), Switzerland (18.2%), Austria (17.2%), France (15.5%), Portugal (15.4%), Belgium (15.3%), UK (14.9%), and Ireland (13.4%). Although the United States (US) is not among the top 15 countries in terms of market share of electric vehicles, it ranks third in terms of market size, trailing China and Europe. By 2020, Europe has surpassed China as the region that has consistently dominated the world's largest electric vehicle market in terms of sales growth since 2012 (Perkins, 2021).

In addition, in the process of transitioning from internal combustion engine vehicle (ICEV) to more environmentally friendly EVs, almost all countries still face no small obstacles except for Norway. Scholars (Carranza *et al.*, 2014; D'Egmont, 2015; Olson, 2018) studied EVs in Norway and discovered that while the country faced some obstacles, such as higher EVs costs relative to ICEVs and limited charging infrastructure, the Norwegian government can overcome these obstacles through incentives and a clear objective plan to build adequate charging infrastructure. Biresselioglu *et al.* (2018) performed research. on electric mobility in Europe and identified hurdles to widespread EV adoption as a scarcity of charging infrastructure, growing electric vehicle prices, lengthy charging times, higher EV electricity consumption, and a scarcity of battery raw materials. Greene *et al.*, (2014) investigated the EV transition in the United States and concluded that reasons inhibiting the shift include the uncertainties around EVs technology and the limited impact of governmental regulations. Additionally, they stressed the significance of future studies on EV hurdles to remove associated uncertainties and provide a framework for policy development. Vassileva and Campillo (2017) concluded that a lack of a strong incentive scheme was a potential adoption barrier for Sweden in their analysis of EVs barriers.

2.2 Overview of electric vehicle industry in developing countries

Between 2015 and 2020, the data of market share of new electric vehicle sales in "other countries" (excluding China, Europe, and the United States) was less than 2%, indicating that the majority of countries, particularly developing countries, continue to face barriers to EV adoption (IEA, 2021). The absence of a developed country's market structure, network infrastructure, and economy are the primary reasons for developing countries' EV adoption to lag behind developed countries (Asif *et al.*, 2021).

Prakash *et al.* (2018) examined the impediments to widespread EV adoption in India and identified insufficient charging infrastructure, a lack of government incentives, and customer characteristics as significant barriers. Asadi *et al.* (2021) conducted a study on the factors influencing electric vehicle adoption and discovered that range anxiety, after-sales support, and a lack of charging infrastructure in Malaysia were the primary impediments to EV adoption progress. Bigot (2020) studied electric vehicles in Russia and discovered that the slow adoption of EVs is primarily due to the high cost of EVs, harsh winter weather conditions, and a lack of charging infrastructure; however, Russia's charging infrastructure is expanding and will overcome this barrier in the future (Habich-Sobiegalla *et al.*, 2018) concluded a study on the purchase intentions of electric vehicles in Brazil and discovered the high cost of EVs in comparison to ICEVs and the lack of public infrastructure in Brazil. Moeletsi (2021) surveyed EV barriers in Gauteng, South Africa, and discovered that the primary factors influencing people's unwillingness to purchase an electric vehicle were the vehicle's high purchase price and high battery costs.

However, although the process of EV adoption in developing countries is arguably slow to non-existent, even research on EV adoption in developing countries is still scarce (Asif *et al.*, 2021), some developing countries have set serious goals and long-term plans for EV adoption like India which has set ambitious goals to replace all ICEVs with EVs by 2030 (Chhikara *et al.*, 2021; Das *et al.*, 2019). Malaysia has plans to install 125,000 charging stations by 2030, while Thailand has established a long-term EV policy with a goal of 1.2 million operational EVs by 2036 and 690 charging stations (Schröder *et al.*, 2021), and Africa is targeting to generate 1% of global EVs in South Africa (Wilberforce, 2021).

2.3 Overview of electric vehicle industry in Indonesia

According to CSRI (2019) the Indonesian government has set a target for mass production of electric vehicles (EV) of 20% of total vehicle production by 2025, followed by a policy to stop sales of internal combustion engines (ICEV) by 2040 to achieve net-zero emissions by 2060 (Haryanto *et al.*, 2020), but the progress of electric vehicles in Indonesia is very slow compared to other countries (Yuniza *et al.*, 2021). To help accelerate the transition to electric vehicles in Indonesia, President Joko Widodo issued Presidential Regulation No. 55 of 2019 in the form of incentives to assist the transition from internal combustion engines to an electric vehicle (Maghfiroh *et al.*, 2021). However, there was only 0.15 percent of EVs on the road at the end of September 2020 (IESR, 2021). According to Yuniza *et al.* (2021), the incentives offered by the government in the presidential regulation were not enough to attract the attention of EVs in the Indonesian market. Apart from the lack of attractive government incentives, there are other barriers to the adoption of electric vehicles in Indonesia, including the high price of electric vehicles, a scarcity of spare parts and repair and maintenance services, an insufficient amount of charging infrastructure, limited battery life, a lack of public awareness, slow charging speeds, range anxiety, and a scarcity of models (Haryanto *et al.*, 2020; Huda *et al.*, 2019; Natalia *et al.*, 2020; Sidabutar, 2020; Sirait, 2020; Utami *et al.*, 2020).

However, the challenge of high electric vehicle prices will not be a major issue in Indonesia in the future (Thorn, 2021), as Indonesia is abundant in raw materials such as nickel and cobalt, which are the primary components of electric vehicle batteries, Unfortunately, the technology and infrastructure required to process these raw materials remain extremely limited, forcing Indonesia to continue importing them from abroad (Setiawan, 2021).

2.4 Identifications of drivers and barriers of electric vehicles adoption in Indonesia

2.4.1 High up-front purchase price: The high initial purchase price is one of the impediments to electric vehicle adoption in Indonesia (Sidabutar, 2020). The average purchasing power of cars in Indonesia is around 200 million (Prasetyo, 2021), while the cheapest electric vehicle in Indonesia, the DFSK Gelora E, costs 480 million Rupiah (Zigwheels, 2022), or more than 200 percent higher than the average purchasing power of cars in Indonesia. This results in consumers in Indonesia preferring internal combustion engines as their primary choice. The high price of electric vehicles in Indonesia is a result of high battery prices, as Indonesia continues to import batteries from China, which serve as the primary raw material for electric vehicles (Umah, 2021).

2.4.2 Range anxiety: Numerous studies have identified consumer range anxiety as one of the significant barriers to the adoption of electric vehicles (Liao *et al.*, 2017; Maghfiroh *et al.*, 2021; Marciano & Christian, 2020). This is undoubtedly true when the drivers notice power depletion while driving are unsure how far they can travel on their remaining battery charge, or when trips are suddenly extended (Graham-Rowe *et al.*, 2012). The uncertainty about the range of an electric vehicle's single charge or remaining battery forces drivers to reconsider using electric vehicles for lengthy trips (She *et al.*, 2017).

2.4.3 Insufficient amount of charging infrastructure: The lack of charging infrastructure is a major impediment to the adoption of electric vehicles in Indonesia (Raksodewanto, 2020). As the infrastructure that facilitates the primary fuel source for electric vehicles, charging stations are critical to the adoption of electric vehicles. However, Indonesia is still far short of the target of 25,000 gas stations by 2030, with only 200 charging stations in total currently operational due to the high cost of gas station installation in Indonesia. The charging infrastructure installed in Indonesia is currently insignificant in comparison to the number of gas stations, leading potential buyers of Indonesian electric vehicles to assume that Indonesia is still not fully prepared to transition to electric vehicles (Jati, 2021).

2.4.4 Low availability of spare parts and, repairing and maintenance services: The availability of dealers, suppliers, and electric vehicle services is still extremely limited in Indonesia (GEM INDONESIA, 2020; Khadafi, 2018), owing to the fact that electric vehicle adoption is still in the "early adopter" phase, which encourages dealers to sell ICEVs rather than EVs due to the longer anticipated sales time, lack of knowledge and competence required to sell, lower profitability for dealers, lower after-sales revenue from services, and the complexity required to install charging points (SEAI, 2020).

2.4.5 Limited battery life: A hurdle to the widespread adoption of electric vehicles is limited battery life, as stated (GEM INDONESIA, 2020) during an Electric Vehicles Indonesia webinar. Batteries are the main source of power for electric vehicles, but these batteries can only last 8 to 10 years of use. When the battery capacity drops below 80%, the user must replace it with a new battery as it is deemed insufficient for transportation applications (Pelletier *et al.*, 2014) and it requires additional costs for battery replacement.

2.4.6 Fewer electric vehicle models: Another barrier to the widespread adoption of electric vehicles is the narrow market for EV models (Haddadian *et al.*, 2015). The limited number of electric vehicle models (lack of variety) circulating in Indonesia makes the electric vehicle market unable to meet all consumer needs and preferences. At the moment, there are only 18 different electric vehicle models scattered throughout Indonesia. Table 1 shows some of the popular EV brands in Indonesia.

Table 1. Popular brands selling EVs in Indonesia

Brand	Models	Years of Active	Type of EV	Logo	Country
Tesla	Tesla Model S	2012 - Present	BEV		The United States
	Tesla Model X	2015 – Present	BEV		
	Tesla Model 3	2017 - Present	BEV		
BMW	BMW i3s	2013 - Present	ER-EV		Germany
	BMW i8	2014 - 2020	PHEV		
	X5 Plug-in Hybrid	2014 – Present	PHEV		
Hyundai	Hyundai IONIQ Prime	2016 – Present	BEV		South Korea
	Hyundai Kona Electric	2017 - Present	HEV		
Nissan	Nissan LEAF	2010 - Present	BEV		Japan
	Nissan kicks-e POWER	2016 - Present	BEV		
Porsche	Porsche Taycan Turbo S	2019 - Present	BEV		Germany
DFSK	DFSK Gelora E	2021 - Present	BEV		China
Mitsubishi	Mitsubishi Outlander	2021 - Present	PHEV		Japan
Toyota	C-HR Hybrid	2016 - Present	HEV		Japan
	Corolla Altis	2018 - Present	HEV		
	Camry	2019 - Present	HEV		
	Lexus UX 300e	2019 - Present	BEV		
	Corolla Cross Hybrid	2020 - Present	HEV		

2.4.7 Lack of public awareness: A lack of public awareness is one of the issues leading to the delayed adoption of electric vehicles (Fortuna, 2019; Lambert, 2017). Although electric car development is still in its infancy, the reality is that many Indonesians are unfamiliar with the technology and some are unaware of the possibility to drive an electric vehicle (EV) (Aziz *et al.*, 2020). This illustrates that public awareness of electric vehicles in Indonesia is extremely low.

2.4.8 Lack of government incentives and support: To encourage the adoption of electric vehicles in Indonesia, President Joko Widodo issued Presidential Regulation Number 55 of 2019 concerning the Battery Electric Vehicle Acceleration Program for Road Transportation (BEV Regulation). The Presidential Regulation contains provisions aimed at accelerating vehicle adoption. Although articles 19 and 20 of the Presidential Regulation include fiscal and non-fiscal incentives, the fact is that the number of electric vehicles in Indonesia remains low, this is due to the lack of attractive incentives from the government to accelerate the adoption of electric vehicles (Yuniza *et al.*, 2021). Of the 17 fiscal and non-fiscal incentives, only four are directed to consumers, while the rest are directed to companies. Table 2 shows both fiscal and non-fiscal incentives contained in Presidential Regulation No. 55 of 2019 on electric vehicles.

These fiscal and non-fiscal incentives are deemed less attractive and are unlikely to result in a significant change in the absence of a subsidy policy for vehicle prices (Yuniza *et al.*, 2021). It is unfortunate because some incentive policies, like purchasing subsidies and tax exemptions, are more effective than others, particularly when some incentive policies are targeted at particular groups (Li *et al.*, 2019). As a result, the primary point of contention is the EV's exclusivity. Additionally, the cost of a single electric vehicle unit remains high in comparison to conventional vehicles. Several countries, including China, the United States, and France, have implemented price reductions or subsidies as a central policy (Volkswagen, 2019). For instance, China has an incentive system in place that entails the waiver of certain prohibitions. In major Chinese cities, electric vehicles are exempt from registration requirements and driving restrictions that apply to vehicles with combustion engines on certain days. The United States utilizes tax credits and exemptions. By purchasing an electric vehicle, users can avoid all federal taxes associated with gasoline

Table 2. Electric Vehicle Incentives in Presidential Regulation No. 55 of 2019

Fiscal Incentives (Article 19)	Non-fiscal incentives (Article 20)
- Import duty incentives for BEV imports; - Sales tax breaks for high-end goods; - Central and local tax incentives or reductions; - Incentives for import duties on machinery, goods, and materials in the context of investment; - Duty suspension in the context of export; - Government-funded duty incentives on the import of raw materials and/or auxiliary materials used in the production line; - Incentives for the manufacture of charging station equipment; - Export financing incentives; - Fiscal incentives for research, development, and technological innovation activities, as well as industrial vocational components, for Battery-Powered Electric Vehicles; - Parking rates at areas designated by the Regional Government; - Cost-cutting measures for charging electricity at charging stations; - Assistance with the construction of charging station infrastructure; - Professional competency certification for resource-based electric vehicle industry personnel; and - Product certification and/or technical standards for battery-based electric vehicle industry companies and component manufacturers.	- Exemptions from certain road usage restrictions; - Delegation of production rights for BEV-related technology for which the Central Government and/or Regional Governments have obtained a patent license; - Promoting security and/or ensuring the industrial sector's operational activities in order to maintain the continuity or reliable performance of logistics and/or manufacturing operations for particular industrial enterprises that are critical to the national economy.

Source: Presiden Republik Indonesia (2019) consumption. France offers an incentive program to encourage the purchase of electric vehicles. The maximum amount eligible for subsidy is 8,500 euros per electric vehicle purchase (Volkswagen, 2019). Table 3 summarizes important literature on drivers and barriers to electric vehicle adoption.

3. Grey ordinal priority approach

Multiple attribute decision-making techniques are frequently used for evaluation and assessment of multiple factors against multiple conflicting attributes. The Ordinal Priority Approach (OPA) is a new technique for multiple attribute decision-making that was proposed in 2020 by Amin Mahmoudi and colleagues and is a very useful tool to help make complex decisions confidently (Mahmoudi & Javed, 2022a). It has seen several applications in just a short span of time. For instance, Quartey-Papafio *et al.* (2021) used the OPA to evaluate healthcare suppliers. Mahmoudi and Javed (2022b) used the OPA to evaluate Iranian construction sub-contractors. Bah and Tulkinov (2022) used the OPA to rank the automotive parts suppliers. Mahmoudi *et al.* (2021c) showed the feasibility of the OPA for handling big data. Scholars have attempted to extend the OPA to solve new problems. Mahmoudi *et al.* (2021a) proposed the fuzzy Ordinal Priority Approach to evaluate green and resilient suppliers. Pamucar *et al.* (2022) also extended OPA in fuzzy environment to prioritize transport planning strategies. Abdel-Basset *et al.* (2022) extended OPA under neutrosophic environment for evaluation of robots.

One of the major breakthroughs in the OPA theory was the development of Grey Ordinal Priority Approach (OPA-G), which was proposed by Mahmoudi *et al.* (2021b). The model combined the benefits of the grey number theory and the OPA. Later, Shajedul (2022) validated the OPA-G model by evaluating sustainable agricultural technologies. The OPA-G model does

Table 3. The summary of drivers and barriers to electric vehicle adoption

Year	Description	Region of focus	Methodology	Reference
2014	The study identified the relationship between financial incentives and other socio-economic factors to EV adoption	N/A	Multiple Linear Regression (MLR) analysis	Sierzchula *et al.* (2014)
2017	The study identified the barriers that can hamper the transition to EV in BRICS Countries	Brazil, Russia, India, China, and South Africa	Descriptive Study (Case Analysis)	Pratiwi (2016)
2019	The Study explores barriers to the uptake of plug-in Electric Vehicles (EV)	Ireland	Descriptive Study (Case study)	O'Neill *et al.* (2019)
2020	The study identified the challenges and rank the barriers to the use of Electric Vehicles (EV)	Nepal	Analytical Hierarchy Process (AHP)	Adhikari *et al.* (2020)
2020	The study identified the strategies and challenges in Electrical Vehicles (EV) adoption	Indonesia	System dynamics	Natalia *et al.* (2020)
2020	The study identified the drivers and barriers to different types of Electric Vehicle (EV) adoption	Developing countries	Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA)	Rajper and Albrecht (2020)
2021	The study identified the drivers, barriers, and support mechanisms of transition from ICE to EVs	India	Qualitative approach	Chhikara *et al.* (2021)
2021	The study identified the contextual preferential set of EV barriers	India	Best-Worst Method (BWM) and Interpretive Structural Modeling (ISM)	Tarei *et al.* (2021)
2022	The Study identified the factors which affect consumer's intention to EV	Malaysia	Decision-Making Trials and Evaluation Laboratory (DEMATEL)	Asadi *et al.* (2022)
2022	This study will identify the drivers and barriers to Electric Vehicle (EV) adoption	Indonesia	Grey Ordinal Priority Approach (OPA-G)	The current study

not require input data to be linguistic variables or pairwise comparisons, but it can present expert, criteria, and alternative weights. Defining sets, indexes, variables, and parameters is necessary prior to introduce OPA-G. As a result, Table 4 includes all necessary sets, indexes, and variables for comprehending the proposed model.

3.1 Definitions

The following definitions and operations are integral part of the Grey Ordinal Priority Approach (OPA-G) and have been borrowed from Mahmoudi *et al.* (2021b).

DEFINITION 1. Assume we have the grey value $\otimes A$. When no distribution exists for the grey number $\otimes A$, the kernel of the grey number A should be determined as follows.

$$\otimes \hat{A} = \frac{1}{2}\left(\overline{A} + \underline{A}\right) \tag{1}$$

DEFINITION 2. Suppose that we have crisp number A. Therefore, $\otimes A$ has a grey rank in the interval $[Rank(A) - 0.5, Rank(A) + 0.5]$. To convert crisp rank n to grey rank $\otimes n$, Equation 2 can be employed.

$$Rank \otimes n = [n - 0.5, n + 0.5] \tag{2}$$

DEFINITION 3. If the respondent(s) has reservations about choosing between the ranks C and D for a barrier while $C < D$, then the following relation should be used for the grey rank.

$$Rank(\otimes C, \otimes D) = [Rank(C) - 0.5, Rank(D) + 0.5] \tag{3}$$

DEFINITION 4. Let $\otimes A = \left[\overline{A}, \underline{A}\right]$ and $\otimes B = \left[\overline{B}, \underline{B}\right]$. The main operations between $\otimes A$ and $\otimes B$ have been presented in Equations 4 to 7.

$$\otimes A + \otimes B = \left[\underline{A} + \underline{B}, \overline{A} + \overline{B}\right], \tag{4}$$

$$\otimes A - \otimes B = \otimes A + (-\otimes B) = \left[\underline{A} - \overline{B}, \overline{A} - \underline{B}\right], \tag{5}$$

$$\otimes A \times \otimes B = \left[Min\left\{\underline{A}\,\underline{B}, \overline{A}\,\overline{B}, \overline{A}\,\underline{B}, \underline{A}\,\overline{B}\right\}, Max\left\{\underline{A}\,\underline{B}, \overline{A}\,\overline{B}, \overline{A}\,\underline{B}, \underline{A}\,\overline{B}\right\}\right], \tag{6}$$

$$\frac{\otimes A}{\otimes B} = \otimes A \times \otimes B^{-1} = \left[Min\left\{\frac{\underline{A}}{\underline{B}}, \frac{\underline{A}}{\overline{B}}, \frac{\overline{A}}{\underline{B}}, \frac{\overline{A}}{\overline{B}}\right\}, Max\left\{\frac{\underline{A}}{\underline{B}}, \frac{\underline{A}}{\overline{B}}, \frac{\overline{A}}{\underline{B}}, \frac{\overline{A}}{\overline{B}}\right\}\right] \tag{7}$$

3.2 Algorithm

The steps to extract the weights and ranking of the respondents and the barriers to EV adoption in Indonesia are listed below.

STEP 1. Identify the barriers to electric vehicle adoption in Indonesia.

STEP 2. Identify the respondents based on their knowledge of the problem.

Table 4. Sets, indexes, and variables for OPA-G method

Sets	
I	Sets of respondents $\forall i \in$ I
J	Sets of barriers $\forall j \in$ J
Indexes	
I	Index of the respondents (A, …, K)
J	Index of barriers (1, …, 8)
Variables	
$\otimes Z$	Grey objective function
$\otimes W_{ij}$	Grey weight(importance) of J^{th}barrier based on respondent at I^{th} rank
Parameters	
$\otimes i$	Grey rank of the respondent i
$\otimes j$	Grey rank of the barrier j

STEP 3. Ranking the barriers: In this stage, the respondent(s) should specify the priorities of barriers, and Definitions 2 and 3 should be employed to convert the crisp ranks to grey ranks. Also, Definition 1 can be used to sort grey numbers.

STEP 4. Solving the OPA-G model, finding the weights of the barriers, and ranking the barriers: Based on the collected data in Steps 1 to 3, the linear model 8 should be formed.

$$
\begin{aligned}
&\text{Max} \otimes Z \\
&\text{S.t:} \\
&\otimes Z \leq \otimes i(\otimes j(\otimes r(\otimes W_{ij}{}^{r} - \otimes W_{ij}{}^{r+1})) \qquad \forall i,j \text{ and } r \\
&\otimes Z \leq \otimes i \otimes j \otimes m \otimes W_{ij}{}^{m} \qquad \forall i \text{ and } j \\
&\textstyle\sum_{i=1}^{p} \sum_{j=1}^{n} \otimes W_{ij} = [0.8,1.2] \\
&\otimes W_{ij} \geq 0 \qquad \forall i \text{ and } j
\end{aligned} \tag{8}
$$

where $\otimes Z$ is unrestricted in sign.

After solving the grey model 8, Equations 9 and 10 should be used to obtain the grey weight of the respondents and barriers. The grey weight of the barriers can be determined using Equation 9.

$$\otimes W_j = \sum_{i=1}^{p} \otimes W_{ij}, \forall j \tag{9}$$

To calculate the grey weights of the respondents, Equation (10) should be utilized.

$$\otimes W_i = \sum_{j=1}^{n} \otimes W_{ij}, \forall i \tag{10}$$

STEP 5. In this step both Grey Possibility Degree and kernel can be used. The current study will use the kernel, which is much easier to calculate. The kernel is given by.

$$\otimes W = \frac{1}{2}(\underline{W} + \overline{W}) \tag{11}$$

4. Results and discussion

4.1 The research instrument

The questionnaire was divided into two parts; the first section aimed to gather demographic information of the respondents. In the second part, respondents were asked fundamental questions about their perceptions of the barriers to electric vehicle adoption in Indonesia. The eight barriers came from section 2.4. The 7-point Likert scale, which is an ordinal scale, was used to collect data where 1 indicated "1st Priority" and 7 indicated "7th Priority". Respondents were asked to assign ranks to each barrier, and were given freedom to assign any rank to any factor based on their viewpoint.

4.2 Data collection

The data collection instrument for this study, a questionnaire, was created and distributed through Google Form targeted at Indonesian citizens. The data was collected from March to April 2022. Thirteen respondents filled the questionnaire but eleven of them knew driving while holding valid driving license. These eleven respondents formed our sample size. The demographic profile of the respondents is shown in Table 5. After converting all data to OPA-G specifications, Lingo software was used to build the OPA-G model and its implementation.

Table 5. The demographic profile of the respondents (N = 11)

Characteristics	Level	Number	%
Age	21 to 30	6	54.5
	31 to 39	2	18.1
	40 to 49	2	18.1
	50 to 59	1	9.1
Marital status	Single	6	54.5
	Married	4	36.3
	Did not answer	1	9.1
City	Jakarta	3	27.2
	Surabaya	2	18.1
	Banyuwangi	1	9.1
	Palembang	1	9.1
	Malang	1	9.1
	Bekasi	1	9.1
	Yogyakarta	1	9.1
	Bandung	1	9.1
Gender	Male	8	72.7
	Female	3	27.2
Educational background	Bachelor (4 year degree)	10	90.9
	High School Diploma	1	9.1
Driving intensity	At least 1 day per week	3	27.2
	At least 4 days per week	2	18.1
	At least 5 days per week	2	27.2
	At least 7 days per week	2	27.2
Purpose of driving	Work, Personal, and Family	6	54.5
	Personal and Family	2	18.1
	Work and Personal	1	9.1
	Work	1	9.1
	Family	1	9.1
Knowledge of Government incentives to support EVs	Know some of the incentives	7	63.6
	Know most of the incentives	2	18.1
	Have no idea of the incentives	2	18.2
Awareness on environmental and pollution-related issues	Aware with the most of the issues	6	54.5
	Aware with the some of the issues	4	36.3
	Have no idea about the issues	1	9.1

4.3 The model

In the current study, eleven respondents and eight barriers/factors were involved and the complete model was very lengthy, and thus is shown in the Appendix. The model was run on LINGO software.

5. Data, results and discussion

The study surveyed eleven respondents with eight separate variables as mentioned in Table 6. It is critical to highlight that all respondents were treated equally in the study. Nonetheless, the the Grey Ordinal Priority Approach (OPA-G) is still capable of calculating the weight of each respondent as well. Tables 7 and 8 indicate the weights and rankings for the barriers and respondents. Equations (9) and (10) are used to determine the barrier and respondent weights. In these tables, A, B, …, K are the respondents/experts, and B1, B2, …, B8 are our barriers. The complete definitions of the barriers are listed below:

Barrier 1 (B1) = High up-front purchase price;

Barrier 2 (B2) = Low availability of spare parts, and repairing and maintenance services;

Barrier 3 (B3) = Insufficient amount of charging infrastructure;

Barrier 4 (B4) = Limited battery life;

Barrier 5 (B5) = Lack of public awareness;

Table 6. Opinion of respondents for factors to electric vehicle adoption in Indonesia

Respondents	Rank Type	B1	B2	B3	B4	B5	B6	B7	B8
A	CR	1	3	1	4	2	2	5	1
	GR	[0.5,1.5]	[2.5,3.5]	[0.5,1.5]	[3.5,4.5]	[1.5,2.5]	[1.5,2.5]	[4.5,5.5]	[0.5,1.5]
B	CR	1	2	2	4	3	3	5	4
	GR	[0.5,1.5]	[1.5,2.5]	[1.5,2.5]	[3.5,4.5]	[2.5,3.5]	[2.5,3.5]	[4.5,5.5]	[3.5,4.5]
C	CR	4	3	4	3	4	4	2	3
	GR	[3.5,4.5]	[2.5,3.5]	[3.5,4.5]	[2.5,3.5]	[3.5,4.5]	[3.5,4.5]	[1.5,2.5]	[2.5,3.5]
D	CR	1	7	4	1	1	1	6	1
	GR	[0.5,1.5]	[6.5,7.5]	[3.5,4.5]	[0.5,1.5]	[0.5,1.5]	[0.5,1.5]	[5.5,6.5]	[0.5,1.5]
E	CR	3	1	3	2	3	4	2	2
	GR	[2.5,3.5]	[0.5,1.5]	[2.5,3.5]	[1.5,2.5]	[2.5,3.5]	[3.5,4.5]	[1.5,2.5]	[1.5,2.5]
F	CR	1	1	1	1	6	1	7	1
	GR	[0.5,1.5]	[0.5,1.5]	[0.5,1.5]	[0.5,1.5]	[5.5,6.5]	[0.5,1.5]	[6.5,7.5]	[0.5,1.5]
G	CR	3	4	5	3	3	3	4	2
	GR	[2.5,3.5]	[3.5,4.5]	[4.5,5.5]	[2.5,3.5]	[2.5,3.5]	[2.5,3.5]	[3.5,4.5]	[1.5,2.5]
H	CR	2	2	1	2	2	2	2	2
	GR	[1.5,2.5]	[1.5,2.5]	[0.5,1.5]	[1.5,2.5]	[1.5,2.5]	[1.5,2.5]	[1.5,2.5]	[1.5,2.5]
I	CR	1	3	1	4	2	2	7	3
	GR	[0.5,1.5]	[2.5,3.5]	[0.5,1.5]	[3.5,4.5]	[1.5,2.5]	[1.5,2.5]	[6.5,7.5]	[2.5,3.5]
J	CR	1	1	2	6	2	5	4	2
	GR	[0.5,1.5]	[0.5,1.5]	[1.5,2.5]	[5.5,6.5]	[1.5,2.5]	[4.5,5.5]	[3.5,4.5]	[1.5,2.5]
K	CR	2	2	2	2	2	2	2	2
	GR	[1.5,2.5]	[1.5,2.5]	[1.5,2.5]	[1.5,2.5]	[1.5,2.5]	[1.5,2.5]	[1.5,2.5]	[1.5,2.5]

Table 7. Weight and ranking of barriers

Barriers	$\underline{W}$	$\overline{W}$	$\otimes W$	Rank
High up-front purchase price	0.159	0.211	0.185	1
Low availability of spare parts, and repairing and maintenance services	0.108	0.159	0.133	4
Insufficient amount of Charging infrastructure	0.125	0.176	0.151	2
Limited battery life	0.078	0.120	0.099	7
Lack of public awareness	0.082	0.141	0.111	6
Range anxiety	0.087	0.136	0.112	5
Fewer Electric Vehicles models	0.045	0.085	0.065	8
Lack of government incentives	0.116	0.173	0.145	3

Table 8. Weights and ranks of the respondents

Respondents	$\underline{W}$	$\overline{W}$	$\otimes W$	Rank
A	0.111	0.164	0.138	1
B	0.070	0.119	0.094	6
C	0.033	0.063	0.048	11
D	0.102	0.128	0.115	2
E	0.070	0.114	0.092	7
F	0.104	0.116	0.110	5
G	0.046	0.091	0.069	8
H	0.052	0.073	0.063	9
I	0.088	0.137	0.112	3
J	0.086	0.135	0.111	4
K	0.038	0.060	0.049	10

Barrier 6 (B6) = Range anxiety;

Barrier 7 (B7) = Fewer Electric Vehicles (EVs) models;

Barrier 8 (B8) = Lack of government incentives.

As shown in Table 7, The high upfront purchase price of electric vehicles is the most significant constraint in Indonesia, followed by an insufficient amount of charging infrastructure in second place and a lack of government incentives in third place, while limited battery life and a lack of electric vehicle models are the two lowest barriers to electric vehicle adoption in Indonesia. Additionally, as shown in Table 8, the OPA-G was successful in determining the rank of each respondent. Whereas respondent 'K' and respondent 'C' are the two least reliable respondents and rank in the bottom two, this is because respondent 'K' answered all core questions with the same answer while respondent C answered all core questions with two consecutively repeated answers. The ranking and weights of the eight barriers to the electric vehicle adoption in Indonesia are shown in Figure 1.

Transportation is critical for connecting people, places, goods, and services, as well as for community development, improving people's quality of life and the economy's overall health. However, it is also a significant source of greenhouse gases. The world, including Indonesia, is attempting to address these issues by shifting to more environmentally friendly energy sources and shifting away from fossil fuel-powered vehicles toward electric vehicles. However, Indonesia is having difficulty adopting electric vehicles; barriers such as a lack of charging infrastructure, the high cost of electric vehicles, and a lack of public awareness all contributed to the slow adoption of EVs. Recognizing the most significant drivers and barriers to electric vehicle adoption can help Indonesia choose the best method to overcome these barriers as well as improve the EVs adoption. Therefore, the current study identified the factors of electric vehicle adoption in Indonesia and applied the OPA-G method to evaluate those factors. After analyzing the responses of all respondents, Table 7 was created. The results indicate that the top three barriers to electric vehicle adoption in Indonesia are a high initial purchase price, an insufficient amount of charging infrastructure, and a lack of government incentives for EVs, followed by a lack of spare parts and repair and maintenance services, range anxiety, a lack of public awareness, a limited battery life, and a lack of EV models.

However, the current study discovered that there is no literature suggesting an uncertain ranking for the barriers to electric vehicle adoption in Indonesia. As a result, the current study used the OPA-G model to account for the uncertainty associated with barriers to electric vehicle adoption and to determine the relative importance of various barriers. With the OPA-G method, decision-makers can truly benefit from a high degree of flexibility when dealing with a variety of electric vehicle-related factors and uncertainties. Additionally, the OPA-G method eliminates the need for data normalization, a pairwise comparison matrix, and opinion aggregation.

6. Conclusion

Climate change and greenhouse gas emissions have become increasingly serious in recent years. While transportation is an integral part of any country, it cannot be denied that it is also a significant

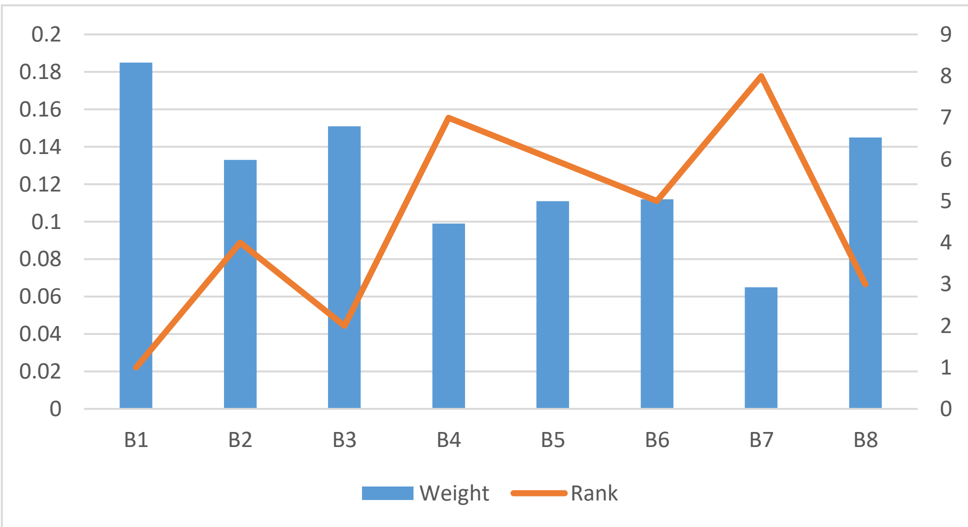

Fig 1. The weights and ranks of the barriers to EV adoption

contributor to greenhouse gases, and Indonesia, as one of the largest emitters, takes this issue seriously. Indonesia is following developed countries' lead in addressing the issue of greenhouse gases by transitioning to electric vehicles that are more environmentally friendly than fossil fuel vehicles. However, the barriers to the adoption of electric vehicles are not insignificant; even Indonesia, Southeast Asia's largest economy, has less than 0.3 percent of electric vehicles due to barriers such as the high cost of electric vehicles in Indonesia, insufficient number of charging infrastructure, and a lack of government incentives. This pushes Indonesia to re-identify and prioritizes the barriers to electric vehicle adoption. There are numerous Multi-Criteria Decision-Making approaches available in the literature to assist decision-makers, but several of these methods are incapable of dealing with information ambiguity. Thus, the Grey Ordinal Priority Approach (OPA-G) was used in this study, a current multi-attribute decision-making technique that assists decision-makers in identifying the barriers to electric car adoption. In Indonesia, choose the best feasible solution for the adoption of electric vehicles.

To combat climate change and greenhouse gas emissions and to achieve carbon neutrality, there is no doubt that transitioning to electric vehicles is one of the best steps the world can take, regardless of the various challenges associated with each country's stage of electric vehicle adoption. This study identified several drivers and barriers to electric vehicle adoption in Indonesia and determined that the high cost of EVs, a lack of charging infrastructure, and a lack of government incentives were the top three barriers to EV adoption. These top three barriers are inextricably linked; by offering more attractive incentives for EVs, such as price subsidies comparable to those offered in China, the United States, and Europe, as well as incentives to boost infrastructure installation, it is possible to increase the number of EVs in Indonesia.

In the future, the OPA-G model can be used to prioritize barriers to EV adaption in other countries as well. In the current study, only one criterion was involved. In the future, more criteria can be considered. Also, barriers like low charging speed can be included in the future.

Acknowledgement

The work is a derivative of the undergraduate thesis of the author submitted to Nanjing University of Information Science and Technology, China, and written under the supervision of Dr. Saad Ahmed Javed. The work is supported by the Natural Science Foundation of the Jiangsu Higher Education Institutions of China (No. 21KJB480011).

Appendix

In the OPA-G model built below, L denotes upper limit, U denotes lower limit and W denotes weights. A, B, … K denotes respondents/experts. The program was written and run on LINGO software.

```
MAX=1/2*ZU+1/2*ZL;
! RESPONDENT A;

1.5*1.5*(WLA1-WLA5)>=ZL;
0.5*0.5*(WUA1-WUA5)>=ZU;
1.5*1.5*(WLA3-WLA5)>=ZL;
0.5*0.5*(WUA3-WUA5)>=ZU;
1.5*1.5*(WLA8-WLA5)>=ZL;
0.5*0.5*(WUA8-WUA5)>=ZU;
1.5*1.5*(WLA1-WLA6)>=ZL;
0.5*0.5*(WUA1-WUA6)>=ZU;
1.5*1.5*(WLA3-WLA6)>=ZL;
0.5*0.5*(WUA3-WUA6)>=ZU;
1.5*1.5*(WLA8-WLA6)>=ZL;
0.5*0.5*(WUA8-WUA6)>=ZU;
1.5*2.5*(WLA5-WLA2)>=ZL;
0.5*1.5*(WUA5-WUA2)>=ZU;
1.5*2.5*(WLA6-WLA2)>=ZL;
0.5*1.5*(WUA6-WUA2)>=ZU;
1.5*3.5*(WLA2-WLA4)>=ZL;
0.5*2.5*(WUA2-WUA4)>=ZU;

! RESPONDENT C;

1.5*2.5*(WLC7-WLC2)>=ZL;
0.5*1.5*(WUC7-WUC2)>=ZU;
1.5*2.5*(WLC7-WLC4)>=ZL;
0.5*1.5*(WUC7-WUC4)>=ZU;
1.5*2.5*(WLC7-WLC8)>=ZL;
0.5*1.5*(WUC7-WUC8)>=ZU;
1.5*3.5*(WLC2-WLC1)>=ZL;
0.5*2.5*(WUC2-WUC1)>=ZU;
1.5*3.5*(WLC4-WLC1)>=ZL;
0.5*2.5*(WUC4-WUC1)>=ZU;
1.5*3.5*(WLC8-WLC1)>=ZL;
0.5*2.5*(WUC8-WUC1)>=ZU;
1.5*3.5*(WLC2-WLC3)>=ZL;
0.5*2.5*(WUC2-WUC3)>=ZU;
1.5*3.5*(WLC4-WLC3)>=ZL;
0.5*2.5*(WUC4-WUC3)>=ZU;
1.5*3.5*(WLC8-WLC3)>=ZL;
0.5*2.5*(WUC8-WUC3)>=ZU;

1.5*4.5*(WLD3-WLD7)>=ZL;
0.5*3.5*(WUD3-WUD7)>=ZU;
1.5*6.5*(WLD7-WLD2)>=ZL;
0.5*5.5*(WUD7-WUD2)>=ZU;
1.5*7.5*(WLD2)>=ZL;
0.5*6.5*(WUD2)>=ZU;

! RESPONDENT E;

1.5*1.5*(WLE2-WLE4)>=ZL;
0.5*0.5*(WUE2-WUE4)>=ZU;
1.5*1.5*(WLE2-WLE7)>=ZL;
0.5*0.5*(WUE2-WUE7)>=ZU;
1.5*1.5*(WLE2-WLE8)>=ZL;
0.5*0.5*(WUE2-WUE8)>=ZU;
1.5*2.5*(WLE4-WLE1)>=ZL;
0.5*1.5*(WUE4-WUE1)>=ZU;
1.5*2.5*(WLE7-WLE1)>=ZL;
0.5*1.5*(WUE7-WUE1)>=ZU;
1.5*2.5*(WLE8-WLE1)>=ZL;
```

```
1.5*4.5*(WLA4-WLA7)>=ZL;
0.5*3.5*(WUA4-WUA7)>=ZU;
1.5*5.5*(WLA7)>=ZL;
0.5*4.5*(WUA7)>=ZU;

! RESPONDENT B;

1.5*1.5*(WLB1-WLB2)>=ZL;
0.5*0.5*(WUB1-WUB2)>=ZU;
1.5*1.5*(WLB1-WLB3)>=ZL;
0.5*0.5*(WUB1-WUB3)>=ZU;
1.5*2.5*(WLB2-WLB5)>=ZL;
0.5*1.5*(WUB2-WUB5)>=ZU;
1.5*2.5*(WLB3-WLB5)>=ZL;
0.5*1.5*(WUB3-WUB5)>=ZU;
1.5*2.5*(WLB2-WLB6)>=ZL;
0.5*1.5*(WUB2-WUB6)>=ZU;
1.5*2.5*(WLB3-WLB6)>=ZL;
0.5*1.5*(WUB3-WUB6)>=ZU;
1.5*3.5*(WLB5-WLB4)>=ZL;
0.5*2.5*(WUB5-WUB4)>=ZU;
1.5*3.5*(WLB6-WLB4)>=ZL;
0.5*2.5*(WUB6-WUB4)>=ZU;
1.5*3.5*(WLB5-WLB8)>=ZL;
0.5*2.5*(WUB5-WUB8)>=ZU;
1.5*3.5*(WLB6-WLB8)>=ZL;
0.5*2.5*(WUB6-WUB8)>=ZU;
1.5*4.5*(WLB4-WLB7)>=ZL;
0.5*3.5*(WUB4-WUB7)>=ZU;
1.5*4.5*(WLB8-WLB7)>=ZL;
0.5*3.5*(WUB8-WUB7)>=ZU;
1.5*5.5*(WLB7)>=ZL;
0.5*4.5*(WUB7)>=ZU;

1.5*3.5*(WLC2-WLC5)>=ZL;
0.5*2.5*(WUC2-WUC5)>=ZU;
1.5*3.5*(WLC4-WLC5)>=ZL;
0.5*2.5*(WUC4-WUC5)>=ZU;
1.5*3.5*(WLC8-WLC5)>=ZL;
0.5*2.5*(WUC8-WUC5)>=ZU;
1.5*3.5*(WLC2-WLC6)>=ZL;
0.5*2.5*(WUC2-WUC6)>=ZU;
1.5*3.5*(WLC4-WLC6)>=ZL;
0.5*2.5*(WUC4-WUC6)>=ZU;
1.5*3.5*(WLC8-WLC6)>=ZL;
0.5*2.5*(WUC8-WUC6)>=ZU;
1.5*4.5*(WLC1)>=ZL;
0.5*3.5*(WUC1)>=ZU;
1.5*4.5*(WLC3)>=ZL;
0.5*3.5*(WUC3)>=ZU;
1.5*4.5*(WLC5)>=ZL;
0.5*3.5*(WUC5)>=ZU;
1.5*4.5*(WLC6)>=ZL;
0.5*3.5*(WUC6)>=ZU;

! RESPONDENT D;

1.5*1.5*(WLD1-WLD3)>=ZL;
0.5*0.5*(WUD1-WUD3)>=ZU;
1.5*1.5*(WLD4-WLD3)>=ZL;
0.5*0.5*(WUD4-WUD3)>=ZU;
1.5*1.5*(WLD5-WLD3)>=ZL;
0.5*0.5*(WUD5-WUD3)>=ZU;
1.5*1.5*(WLD6-WLD3)>=ZL;
0.5*0.5*(WUD6-WUD3)>=ZU;
1.5*1.5*(WLD8-WLD3)>=ZL;
0.5*0.5*(WUD8-WUD3)>=ZU;

0.5*1.5*(WUE8-WUE1)>=ZU;
1.5*2.5*(WLE4-WLE3)>=ZL;
0.5*1.5*(WUE4-WUE3)>=ZU;
1.5*2.5*(WLE7-WLE3)>=ZL;
0.5*1.5*(WUE7-WUE3)>=ZU;
1.5*2.5*(WLE8-WLE3)>=ZL;
0.5*1.5*(WUE8-WUE3)>=ZU;
1.5*2.5*(WLE4-WLE5)>=ZL;
0.5*1.5*(WUE4-WUE5)>=ZU;
1.5*2.5*(WLE7-WLE5)>=ZL;
0.5*1.5*(WUE7-WUE5)>=ZU;
1.5*2.5*(WLE8-WLE5)>=ZL;
0.5*1.5*(WUE8-WUE5)>=ZU;
1.5*3.5*(WLE1-WLE6)>=ZL;
0.5*2.5*(WUE1-WUE6)>=ZU;
1.5*3.5*(WLE3-WLE6)>=ZL;
0.5*2.5*(WUE3-WUE6)>=ZU;
1.5*3.5*(WLE5-WLE6)>=ZL;
0.5*2.5*(WUE5-WUE6)>=ZU;
1.5*4.5*(WLE6)>=ZL;
0.5*3.5*(WUE6)>=ZU;

! RESPONDENT F;

1.5*1.5*(WLF1-WLF5)>=ZL;
0.5*0.5*(WUF1-WUF5)>=ZU;
1.5*1.5*(WLF2-WLF5)>=ZL;
0.5*0.5*(WUF2-WUF5)>=ZU;
1.5*1.5*(WLF3-WLF5)>=ZL;
0.5*0.5*(WUF3-WUF5)>=ZU;
1.5*1.5*(WLF4-WLF5)>=ZL;
0.5*0.5*(WUF4-WUF5)>=ZU;
1.5*1.5*(WLF6-WLF5)>=ZL;

0.5*0.5*(WUF6-WUF5)>=ZU;
1.5*1.5*(WLF8-WLF5)>=ZL;
0.5*0.5*(WUF8-WUF5)>=ZU;
1.5*6.5*(WLF5-WLF7)>=ZL;
0.5*5.5*(WUF5-WUF7)>=ZU;
1.5*7.5*(WLF7)>=ZL;
0.5*6.5*(WUF7)>=ZU;

! RESPONDENT G;

1.5*2.5*(WLG8-WLG1)>=ZL;
0.5*1.5*(WUG8-WUG1)>=ZU;
1.5*2.5*(WLG8-WLG4)>=ZL;
0.5*1.5*(WUG8-WUG4)>=ZU;
1.5*2.5*(WLG8-WLG5)>=ZL;
0.5*1.5*(WUG8-WUG5)>=ZU;
1.5*2.5*(WLG8-WLG6)>=ZL;
0.5*1.5*(WUG8-WUG6)>=ZU;
1.5*3.5*(WLG1-WLG2)>=ZL;
0.5*2.5*(WUG1-WUG2)>=ZU;
1.5*3.5*(WLG4-WLG2)>=ZL;
0.5*2.5*(WUG4-WUG2)>=ZU;
1.5*3.5*(WLG5-WLG2)>=ZL;
0.5*2.5*(WUG5-WUG2)>=ZU;
1.5*3.5*(WLG6-WLG2)>=ZL;
0.5*2.5*(WUG6-WUG2)>=ZU;
1.5*3.5*(WLG1-WLG7)>=ZL;
0.5*2.5*(WUG1-WUG7)>=ZU;
1.5*3.5*(WLG4-WLG7)>=ZL;
0.5*2.5*(WUG4-WUG7)>=ZU;
1.5*3.5*(WLG5-WLG7)>=ZL;
0.5*2.5*(WUG5-WUG7)>=ZU;
1.5*3.5*(WLG6-WLG7)>=ZL;
0.5*2.5*(WUG6-WUG7)>=ZU;
1.5*4.5*(WLG2-WLG3)>=ZL;
0.5*3.5*(WUG2-WUG3)>=ZU;
1.5*4.5*(WLG7-WLG3)>=ZL;
0.5*3.5*(WUG7-WUG3)>=ZU;
1.5*5.5*(WLG3)>=ZL;
0.5*4.5*(WUG3)>=ZU;

! RESPONDENTS H;

1.5*1.5*(WLH3-WLH1)>=ZL;
0.5*0.5*(WUH3-WUH1)>=ZU;
1.5*1.5*(WLH3-WLH2)>=ZL;
0.5*0.5*(WUH3-WUH2)>=ZU;
1.5*1.5*(WLH3-WLH4)>=ZL;
0.5*0.5*(WUH3-WUH4)>=ZU;
1.5*1.5*(WLH3-WLH5)>=ZL;
0.5*0.5*(WUH3-WUH5)>=ZU;
1.5*1.5*(WLH3-WLH6)>=ZL;
0.5*0.5*(WUH3-WUH6)>=ZU;
1.5*1.5*(WLH3-WLH7)>=ZL;
0.5*0.5*(WUH3-WUH7)>=ZU;
1.5*1.5*(WLH3-WLH8)>=ZL;
0.5*0.5*(WUH3-WUH8)>=ZU;
1.5*2.5*(WLH1)>=ZL;
0.5*1.5*(WUH1)>=ZU;
1.5*2.5*(WLH2)>=ZL;
0.5*1.5*(WUH2)>=ZU;
1.5*2.5*(WLH4)>=ZL;
0.5*1.5*(WUH4)>=ZU;
1.5*2.5*(WLH5)>=ZL;
0.5*1.5*(WUH5)>=ZU;
1.5*2.5*(WLH6)>=ZL;
0.5*1.5*(WUH6)>=ZU;
1.5*2.5*(WLH7)>=ZL;
0.5*1.5*(WUH7)>=ZU;
1.5*2.5*(WLH8)>=ZL;
0.5*1.5*(WUH8)>=ZU;

! RESPONDENTS I;

1.5*1.5*(WLI1-WLI5)>=ZL;
0.5*0.5*(WUI1-WUI5)>=ZU;
1.5*1.5*(WLI3-WLI5)>=ZL;
0.5*0.5*(WUI3-WUI5)>=ZU;
1.5*1.5*(WLI1-WLI6)>=ZL;
0.5*0.5*(WUI1-WUI6)>=ZU;
1.5*1.5*(WLI3-WLI6)>=ZL;

0.5*0.5*(WUI3-WUI6)>=ZU;
1.5*2.5*(WLI5-WLI2)>=ZL;
0.5*1.5*(WUI5-WUI2)>=ZU;
1.5*2.5*(WLI6-WLI2)>=ZL;
0.5*1.5*(WUI6-WUI2)>=ZU;
1.5*2.5*(WLI5-WLI8)>=ZL;
0.5*1.5*(WUI5-WUI8)>=ZU;
1.5*2.5*(WLI6-WLI8)>=ZL;
0.5*1.5*(WUI6-WUI8)>=ZU;
1.5*3.5*(WLI2-WLI4)>=ZL;
0.5*2.5*(WUI2-WUI4)>=ZU;
1.5*3.5*(WLI8-WLI4)>=ZL;
0.5*2.5*(WUI8-WUI4)>=ZU;
1.5*4.5*(WLI4-WLI7)>=ZL;
0.5*3.5*(WUI4-WUI7)>=ZU;
1.5*7.5*(WLI7)>=ZL;
0.5*6.5*(WUI7)>=ZU;

! RESPONDENT J;

1.5*1.5*(WLJ1-WLJ3)>=ZL;
0.5*0.5*(WUJ1-WUJ3)>=ZU;
1.5*1.5*(WLJ2-WLJ3)>=ZL;
0.5*0.5*(WUJ2-WUJ3)>=ZU;
1.5*1.5*(WLJ1-WLJ5)>=ZL;
0.5*0.5*(WUJ1-WUJ5)>=ZU;
1.5*1.5*(WLJ2-WLJ5)>=ZL;
0.5*0.5*(WUJ2-WUJ5)>=ZU;
1.5*1.5*(WLJ1-WLJ8)>=ZL;
0.5*0.5*(WUJ1-WUJ8)>=ZU;
1.5*1.5*(WLJ2-WLJ8)>=ZL;
0.5*0.5*(WUJ2-WUJ8)>=ZU;
1.5*2.5*(WLJ3-WLJ7)>=ZL;
0.5*1.5*(WUJ3-WUJ7)>=ZU;
1.5*2.5*(WLJ5-WLJ7)>=ZL;
0.5*1.5*(WUJ5-WUJ7)>=ZU;
1.5*2.5*(WLJ8-WLJ7)>=ZL;
0.5*1.5*(WUJ8-WUJ7)>=ZU;
1.5*4.5*(WLJ7-WLJ6)>=ZL;
0.5*3.5*(WUJ7-WUJ6)>=ZU;
```

```
1.5*5.5*(WLJ6-WLJ4)>=ZL;
0.5*4.5*(WUJ6-WUJ4)>=ZU;
1.5*6.5*(WLJ4)>=ZL;
0.5*5.5*(WUJ4)>=ZU;

! RESPONDENT K;

1.5*2.5*(WLK1)>=ZL;
0.5*1.5*(WUK1)>=ZU;
1.5*2.5*(WLK2)>=ZL;
0.5*1.5*(WUK2)>=ZU;
1.5*2.5*(WLK3)>=ZL;
0.5*1.5*(WUK3)>=ZU;
1.5*2.5*(WLK4)>=ZL;
0.5*1.5*(WUK4)>=ZU;
1.5*2.5*(WLK5)>=ZL;
0.5*1.5*(WUK5)>=ZU;
1.5*2.5*(WLK6)>=ZL;
0.5*1.5*(WUK6)>=ZU;
1.5*2.5*(WLK7)>=ZL;
0.5*1.5*(WUK7)>=ZU;
1.5*2.5*(WLK8)>=ZL;
0.5*1.5*(WUK8)>=ZU;

ZL>=ZU;


WUA1+WUA2+WUA3+WUA4+WUA5+WUA6+WUA7+WUA8+WUB1+WUB2+WUB3+WUA4+WUB5+WUB6+WUB7+WUB8+WUC1+WUC2+WUC3+WUC4+WUC5+WUC6+
WUC7+WUC8+WUD1+WUD2+WUD3+WUD4+WUD5+WUD6+WUD7+WUD8+WUE1+WUE2+WUE3+WUE4+WUE5+WUE6+WUE7+WUE8+WUF1+WUF2+WUF3+WUF4+
WUF5+WUF6+WUF7+WUF8+WUG1+WUG2+WUG3+WUG4+WUG5+WUG6+WUG7+WUG8+WUH1+WUH2+WUH3+WUH4+WUH5+WUH6+WUH7+WUH8+WUI1+WUI2+
WUI3+WUI4+WUI5+WUI6+WUI7+WUI8+WUJ1+WUJ2+WUJ3+WUJ4+WUJ5+WUJ6+WUJ7+WUJ8+WUK1+WUK2+WUK3+WUK4+WUK5+WUK6+WUK7+WUK8=0.8;

WLA1+WLA2+WLA3+WLA4+WLA5+WLA6+WLA7+WLA8+WLB1+WLB2+WLB3+WLA4+WLB5+WLB6+WLB7+WLB8+WLC1+WLC2+WLC3+WLC4+WLC5+WLC6+WLC7+
WLC8+WLD1+WLD2+WLD3+WLD4+WLD5+WLD6+WLD7+WLD8+WLE1+WLE2+WLE3+WLE4+WLE5+WLE6+WLE7+WLE8+WLF1+WLF2+WLF3+WLF4+WLF5+WLF6+
WLF7+WLF8+WLG1+WLG2+WLG3+WLG4+WLG5+WLG6+WLG7+WLG8+WLH1+WLH2+WLH3+WLH4+WLH5+WLH6+WLH7+WLH8+WLI1+WLI2+WLI3+WLI4+WLI5+
WLI6+WLI7+WLI8+WLJ1+WLJ2+WLJ3+WLJ4+WLJ5+WLJ6+WLJ7+WLJ8+WLK1+WLK2+WLK3+WLK4+WLK5+WLK6+WLK7+WLK8=1.2;

WLA1>=WUA1; WLA2>=WUA2; WLA3>=WUA3; WLA4>=WUA4; WLA5>=WUA5; WLA6>=WUA6; WLA7>=WUA7; WLA8>=WUA8; WLB1>=WUB1; WLB2>=WUB2;
WLB3>=WUB3; WLB4>=WUB4; WLB5>=WUB5; WLB6>=WUB6; WLB7>=WUB7; WLB8>=WUB8; WLC1>=WUC1; WLC2>=WUC2; WLC3>=WUC3; WLC4>=WUC4;
WLC5>=WUC5; WLC6>=WUC6; WLC7>=WUC7; WLC8>=WUC8; WLD1>=WUD1; WLD2>=WUD2; WLD3>=WUD3; WLD4>=WUD4; WLD5>=WUD5; WLD6>=WUD6;
WLD7>=WUD7; WLD8>=WUD8; WLE1>=WUE1; WLE2>=WUE2; WLE3>=WUE3; WLE4>=WUE4; WLE5>=WUE5; WLE6>=WUE6; WLE7>=WUE7; WLE8>=WUE8;
WLF1>=WUF1; WLF2>=WUF2; WLF3>=WUF3; WLF4>=WUF4; WLF5>=WUF5; WLF6>=WUF6; WLF7>=WUF7; WLF8>=WUF8; WLG1>=WUG1; WLG2>=WUG2;
WLG3>=WUG3; WLG4>=WUG4; WLG5>=WUG5; WLG6>=WUG6; WLG7>=WUG7; WLG8>=WUG8; WLH1>=WUH1; WLH2>=WUH2; WLH3>=WUH3; WLH4>=WUH4;
WLH5>=WUH5; WLH6>=WUH6; WLH7>=WUH7; WLH8>=WUH8; WLI1>=WUI1; WLI2>=WUI2; WLI3>=WUI3; WLI4>=WUI4; WLI5>=WUI5; WLI6>=WUI6; WLI7>=WUI7;
WLI8>=WUI8; WLJ1>=WUJ1; WLJ2>=WUJ2; WLJ3>=WUJ3; WLJ4>=WUJ4; WLJ5>=WUJ5; WLJ6>=WUJ6; WLJ7>=WUJ7; WLJ8>=WUJ8; WLK1>=WUK1; WLK2>=WUK2;
WLK3>=WUK3; WLK4>=WUK4; WLK5>=WUK5; WLK6>=WUK6; WLK7>=WUK7; WLK8>=WUK8;

WUA1>=0; WUA2>=0; WUA3>=0; WUA4>=0; WUA5>=0; WUA6>=0; WUA7>=0; WUA8>=0; WUB1>=0; WUB2>=0; WUB3>=0; WUB4>=0; WUB5>=0; WUB6>=0; WUB7>=0;
WUB8>=0; WUC1>=0; WUC2>=0; WUC3>=0; WUC4>=0; WUC5>=0; WUC6>=0; WUC7>=0; WUC8>=0; WUD1>=0; WUD2>=0; WUD3>=0; WUD4>=0; WUD5>=0; WUD6>=0;
WUD7>=0; WUD8>=0; WUE1>=0; WUE2>=0; WUE3>=0; WUE4>=0; WUE5>=0; WUE6>=0; WUE7>=0; WUE8>=0; WUF1>=0; WUF2>=0; WUF3>=0; WUF4>=0; WUF5>=0;
WUF6>=0; WUF7>=0; WUF8>=0; WUG1>=0; WUG2>=0; WUG3>=0; WUG4>=0; WUG5>=0; WUG6>=0; WUG7>=0; WUG8>=0; WUH1>=0; WUH2>=0; WUH3>=0; WUH4>=0;
WUH5>=0; WUH6>=0; WUH7>=0; WUH8>=0; WUI1>=0; WUI2>=0; WUI3>=0; WUI4>=0; WUI5>=0; WUI6>=0; WUI7>=0; WUI8>=0; WUJ1>=0; WUJ2>=0; WUJ3>=0;
WUJ4>=0; WUJ5>=0; WUJ6>=0; WUJ7>=0; WUJ8>=0; WUK1>=0; WUK2>=0; WUK3>=0; WUK4>=0; WUK5>=0; WUK6>=0; WUK7>=0; WUK8>=0;
```

References

Abdel-Basset, M., Mohamed, M., Abdel-Monem, A., & Elfattah, M. A. (2022). New extension of ordinal priority approach for multiple attribute decision-making problems: design and analysis. *Complex & Intelligent Systems*. https://doi.org/10.1007/s40747-022-00721-w

Adhikari, M., Ghimire, L. P., Kim, Y., Aryal, P., & Khadka, S. B. (2020). Identification and analysis of barriers against electric vehicle use. *Sustainability*, *12*(12), 1–20. https://doi.org/10.3390/SU12124850

Asadi, S., Nilashi, M., Iranmanesh, M., Ghobakhloo, M., Samad, S., Alghamdi, A., Almulihi, A., & Mohd, S. (2022). Drivers and barriers of electric vehicle usage in Malaysia: A DEMATEL approach. *Resources, Conservation and Recycling*, *177*, 105965. https://doi.org/10.1016/j.resconrec.2021.105965

Asadi, S., Nilashi, M., Samad, S., Abdullah, R., Mahmoud, M., Alkinani, M. H., & Yadegaridehkordi, E. (2021). Factors impacting consumers' intention toward adoption of electric vehicles in Malaysia. *Journal of Cleaner Production*, *282*, 124474. https://doi.org/10.1016/j.jclepro.2020.124474

Asif, M., Jajja, M. S. S., & Searcy, C. (2021). A Review of Literature on the Antecedents of Electric Vehicles Promotion: Lessons for Value Chains in Developing Countries. *IEEE Transactions on Engineering Management*. https://doi.org/10.1109/tem.2021.3099070

Aziz, M., Marcellino, Y., Rizki, I. A., Ikhwanuddin, S. A., & Simatupang, J. W. (2020). Analysis of Technological Developments and Indonesian Government Support for Electric Cars [Studi Analisis Perkembangan Teknologi Dan Dukungan Pemerintah Indonesia Terkait Mobil Listrik]. *TESLA: Jurnal Teknik Elektro*, *22*(1), 45. https://doi.org/10.24912/tesla.v22i1.7898

Bah, M. K., & Tulkinov, S. (2022). Evaluation of Automotive Parts Suppliers through Ordinal Priority Approach and TOPSIS. *Management Science and Business Decisions*, *2*(1), 5–17. https://doi.org/10.52812/msbd.37

Bakker, G. (2021). Infrastructure killed the electric car. *Nature Energy*, *6*(10), 947–948. https://doi.org/10.1038/s41560-021-00902-w

Bigot, S. (2020). *8 things to know about electric cars in Russia*. Eurasia Network. https://eurasianetwork.eu/2017/08/19/7-things-to-know-about-electric-cars-in-russia/

Biresselioglu, M. E., Demirbag Kaplan, M., & Yilmaz, B. K. (2018). Electric mobility in Europe: A comprehensive review of motivators and barriers in decision making processes. *Transportation Research Part A: Policy and Practice*, *109*, 1–13. https://doi.org/10.1016/j.tra.2018.01.017

Carranza, F., Paturet, O., & Salera, S. (2014). *Norway, the most successful market for electric vehicles*. Proceedings of the 2013 World Electric Vehicle Symposium and Exhibition (EVS27). https://doi.org/10.1109/EVS.2013.6915005

Chhikara, R., Garg, R., Chhabra, S., Karnatak, U., & Agrawal, G. (2021). Factors affecting adoption of electric vehicles in India: An exploratory study. *Transportation Research Part D: Transport and Environment*, *100*, 103084. https://doi.org/10.1016/j.trd.2021.103084

CSRI. (2019). *Gov't to Mass Produce EV By 2025, Minister Says*. Cabinet Secretariat of The Republic of Indonesia. https://setkab.go.id/en/govt-to-mass-produce-ev-by-2025-minister-says/

D'Egmont, R. (2015). Electric Vehicles: The Norwegian Experience in Overcoming Barriers. *Bellona Europa*, *32*(0), 2–5. https://bellona.org/assets/sites/4/Bellona-EV-Brief_The-Norwegian-Success-Story1.pdf

Das, M. C., Pandey, A., Mahato, A. K., & Singh, R. K. (2019). Comparative performance of electric vehicles using evaluation of mixed data. *Opsearch*, *56*(3), 1067–1090. https://doi.org/10.1007/s12597-019-00398-9

Degirmenci, K., & Breitner, M. H. (2017). Consumer purchase intentions for electric vehicles: Is green more important than price and range? *Transportation Research Part D: Transport and Environment*, *51*, 250–260. https://doi.org/10.1016/j.trd.2017.01.001

Ehrenberger, S. I., Dunn, J. B., Jungmeier, G., & Wang, H. (2019). An international dialogue about electric vehicle deployment to bring energy and greenhouse gas benefits through 2030 on a well- to-wheels basis. *Transportation Research Part D: Transport and Environment*, *74*, 245–254. https://doi.org/10.1016/j.trd.2019.07.027

Fortuna, C. (2019). *If We Want To See More EV Adoption, We Need To Educate The Masses*. CleanTechnica. https://cleantechnica.com/2019/03/31/if-we-want-to-see-more-ev-adoption-we-need-to-educate-the-masses/

GEM INDONESIA. (2020). *Electric Vehicle Indonesia Webinar 2020 - Part 1*. YouTube. https://www.youtube.com/watch?v=hRwREU6iskU&t=2574s&ab_channel=GEMINDONESIA

Graham-Rowe, E., Gardner, B., Abraham, C., Skippon, S., Dittmar, H., Hutchins, R., & Stannard, J. (2012). Mainstream consumers driving plug-in battery-electric and plug-in hybrid electric cars: A qualitative analysis of responses and evaluations. *Transportation Research Part A: Policy and Practice*, *46*(1), 140–153. https://doi.org/10.1016/j.tra.2011.09.008

Greene, D. L., Park, S., & Liu, C. (2014). Analyzing the transition to electric drive vehicles in the U.S. *Futures*, *58*, 34–52. https://doi.org/10.1016/j.futures.2013.07.003

Grupta, R., & Hansmann, T. (2021). *Growing demand for electric vehicles a boost for Indonesia's economy – Opinion*. The Jakarta Post. https://www.thejakartapost.com/academia/2021/05/27/growing-demand-for-electric-vehicles-a-boost-for-indonesias-economy.html

Habich-Sobiegalla, S., Kostka, G., & Anzinger, N. (2018). Electric vehicle purchase intentions of Chinese, Russian and Brazilian citizens: An international comparative study. *Journal of Cleaner Production*, *205*, 188–200. https://doi.org/10.1016/j.jclepro.2018.08.318

Haddadian, G., Khodayar, M., & Shahidehpour, M. (2015). Accelerating the Global Adoption of Electric Vehicles: Barriers and Drivers. *Electricity Journal*, *28*(10), 53–68. https://doi.org/10.1016/j.tej.2015.11.011

Haryanto, A. T., Utami, M. W. Dela, & Sutopo, W. (2020). Consumer perception analysis of electric car vehicle in Indonesia. *AIP Conference Proceedings*, *2217*. https://doi.org/10.1063/5.0000541

Huda, M., Aziz, M., & Tokimatsu, K. (2019). The future of electric vehicles to grid integration in Indonesia. *Energy Procedia*, *158*(2018), 4592–4597. https://doi.org/10.1016/j.egypro.2019.01.749

IEA. (2020). *Global EV Outlook 2020 – Analysis*. IEA. https://www.iea.org/reports/global-ev-outlook-2020

IEA. (2021). *Global EV Outlook 2021 - Accelerating ambitions despite the pandemic*. Global EV Outlook 2021, 101. https://iea.blob.core.windows.net/assets/ed5f4484-f556-4110-8c5c-4ede8bcba637/GlobalEVOutlook2021.pdf

IESR. (2021). *Indonesia Energy Transition Outlook 2021*. Institute for Essential Services Reform, 1–93. https://iesr.or.id/en/pustaka/indonesia-energy-transition-outlook-ieto-2021

IQAir. (2022). *Indonesia Air Quality Index (AQI) and Air Pollution information* | AirVisual. IQAir. https://www.iqair.com/indonesia

Jati, G. (2021). *The Government's Electric Vehicle Infrastructure Target is Still Creating Range Anxiety*. Institute for Essential Services Reform. https://iesr.or.id/en/the-governments-electric-vehicle-infrastructure-target-is-still-creating-range-anxiety

Khadafi, M. (2018). *ELECTRIC VEHICLES: Spare Parts Industry Needs Incentives* [KENDARAAN LISTRIK: Industri Suku Cadang Butuh Insentif]. Otomotif.Bisnis. https://otomotif.bisnis.com/read/20180703/275/811973/kendaraan-listrik-industri-suku-cadang-butuh-insentif

Khalili, S., Rantanen, E., Bogdanov, D., & Breyer, C. (2019). Global transportation demand development with impacts on the energy demand and greenhouse gas emissions in a climate-constrained world. *Energies*, *12*(20). https://doi.org/10.3390/en12203870

Krishna, G. (2021). Understanding and identifying barriers to electric vehicle adoption through thematic analysis. *Transportation Research Interdisciplinary Perspectives*, *10*, 100364. https://doi.org/10.1016/j.trip.2021.100364

Lambert, F. (2017). *Lack of awareness is surprisingly still the biggest problem for electric vehicle adoption*. Electrek. https://electrek.co/2017/01/03/electric-vehicle-adoption-awareness/

Lambert, F. (2022, February 2). *Global market share of electric cars more than doubled in 2021 as the EV revolution gains steam*. Electrek. https://electrek.co/2022/02/02/global-market-share-of-electric-cars-more-than-doubled-2021/

Li, W., Long, R., Chen, H., Chen, F., Zheng, X., & Yang, M. (2019). Effect of policy incentives on the uptake of electric vehicles in China. *Sustainability*, *11*(12), 1–20. https://doi.org/10.3390/su10023323

Liao, F., Molin, E., & van Wee, B. (2017). Consumer preferences for electric vehicles: a literature review. *Transport Reviews*, *37*(3), 252–275. https://doi.org/10.1080/01441647.2016.1230794

Maghfiroh, M. F. N., Pandyaswargo, A. H., & Onoda, H. (2021). Current readiness status of electric vehicles in indonesia: Multistakeholder perceptions. *Sustainability*, *13*(23), 1–25. https://doi.org/10.3390/su132313177

Mahmoudi, A., & Javed, S. A. (2022a). Probabilistic Approach to Multi-Stage Supplier Evaluation: Confidence Level Measurement in Ordinal Priority Approach. *Group Decision and Negotiation*. https://doi.org/10.1007/s10726-022-09790-1

Mahmoudi, A., & Javed, S.A. (2022b). Performance Evaluation of Construction Sub-contractors using Ordinal Priority Approach. *Evaluation and Program Planning*, *91*, 102022. https://doi.org/10.1016/j.evalprogplan.2021.102022

Mahmoudi, A., Deng, X., Javed, S. A., & Yuan, J. (2021c). Large-Scale Multiple Criteria Decision-Making with Missing Values: Project Selection through TOPSIS-OPA. *Journal of Ambient Intelligence and Humanized Computing*, *12*, 9341–9362. https://doi.org/10.1007/s12652-020-02649-w

Mahmoudi, A., Deng, X., Javed, S. A., & Zhang, N. (2021b). Sustainable Supplier Selection in Megaprojects through Grey Ordinal Priority Approach. *Business Strategy and The Environment*, *30*, 318-339. https://doi.org/10.1002/bse.2623

Mahmoudi, A., Javed, S.A., & Mardani, A. (2021a). Gresilient Supplier Selection through Fuzzy Ordinal Priority Approach: Decision-making in Post-COVID era. *Operations Management Research*. https://doi.org/10.1007/s12063-021-00178-z

Marciano, I., & Christian, J. A. (2020). *The Role of Electric Vehicles in Decarbonizing Indonesia's Road Transport Sector*. Institute for Essential Services Reform. https://iesr.or.id/en/pustaka/the-role-of-electric-vehicles-in-decarbonizing-indonesias-road-transport-sector

Moeletsi, M. E. (2021). Socio-economic barriers to adoption of electric vehicles in South Africa: Case study of the gauteng province. *World Electric Vehicle Journal*, *12*(4), 1–11. https://doi.org/10.3390/wevj12040167

Natalia, Y., Rahman, I., & Hidayatno, A. (2020). Conceptual Model for Understanding the Policy Challenges of Electric Vehicle Adoption in Indonesia. PervasiveHealth: *Pervasive Computing Technologies for Healthcare*, 113–117. https://doi.org/10.1145/3429551.3429557

O'Neill, E., Moore, D., Kelleher, L., & Brereton, F. (2019). Barriers to electric vehicle uptake in Ireland: Perspectives of car-dealers and policy-makers. *Case Studies on Transport Policy*, *7*(1), 118–127. https://doi.org/10.1016/j.cstp.2018.12.005

Olson, E. L. (2018). Lead market learning in the development and diffusion of electric vehicles. *Journal of Cleaner Production*, *172*, 3279–3288. https://doi.org/10.1016/j.jclepro.2017.10.318

Pamucar, D., Deveci, M., Gokasar, I., Martínez, L., & Köppen, M. (2022). Prioritizing Transport Planning Strategies for Freight Companies Towards Zero Carbon Emission Using Ordinal Priority Approach. *Computers & Industrial Engineering*, 108259. https://doi.org/10.1016/j.cie.2022.108259

Pelletier, S., Jabali, O., & Laporte, G. (2014). *Battery Electric Vehicles for Goods Distribution: A Survey of Vehicle Technology, Market Penetration, Incentives and Practices* (CIRRELT-2014-43). CIRRELT, September, 51. https://www.cirrelt.ca/documentstravail/cirrelt-2014-43.pdf

Perkins, R. (2021). *Europe overtakes China in EV sales growth in 2020*. S&P Global. https://www.spglobal.com/platts/en/market-insights/latest-news/coal/012021-europe-overtakes-china-in-ev-sales-growth-in-2020

Prakash, S., Dwivedy, M., Poudel, S. S., & Shrestha, D. R. (2018). *Modelling the barriers for mass adoption of electric vehicles in Indian automotive sector: An Interpretive Structural Modeling (ISM) approach*. 2018 5th International Conference on Industrial Engineering and Applications, ICIEA 2018, 458–462. https://doi.org/10.1109/IEA.2018.8387144

Prasetyo, W. B. (2021). *The Price of Electric Cars Is Expensive, There Needs To Be Incentives* [Harga Mobil Listrik Mahal, Perlu Ada Insentif]. Beritasatu. https://www.beritasatu.com/otomotif/862807/harga-mobil-listrik-mahal-perlu-ada-insentif

Pratiwi, L. (2016). Barriers and Strategies for Transition to Electric Vehicles in BRICS Countries. TU Delft Library. https://repository.tudelft.nl/islandora/object/uuid%3A0b25e361-31ec-4cbf-9653-1e8764ce1864

Presiden Republik Indonesia. (2019). *Presidential Regulation Number 55 of 2019 concerning the Acceleration Program for Battery Electric Vehicles for Road Transportation* [Peraturan Presiden Nomor 55 Tahun 2019 Tentang Percepatan program Kendaraan Bermotor Listrik Berbasis Baterai] (Battery Electric Vehicle) Untuk Transportasi Jalan. Republik Indonesia, 55.

PWYP. (2019). *Energy Efficiency in the Transportation Sector, Case Studies in Indonesia and the European Union*. PWYP Indonesia. https://pwypindonesia.org/en/energy-efficiency-in-the-transportation-sector-case-studies-in-indonesia-and-the-european-union/

Quartey-Papafio, T. K., Shajedul, I., & Dehaghani, A. R. (2021). Evaluating Suppliers for Healthcare Centre using Ordinal Priority Approach. *Management Science and Business Decisions*, *1*(1), 5-11. https://doi.org/10.52812/msbd.12

Rajper, S. Z., & Albrecht, J. (2020). Prospects of electric vehicles in the developing countries: A literature review. *Sustainability*, *12*(5). https://doi.org/10.3390/su12051906

Raksodewanto, A. A. (2020). *Compare Electric Car With Conventional Car* [Membandingkan mobil listrik dengan mobil konvensional], 89–92. http://technopex.iti.ac.id/ocs/index.php/tpx20/tpx20/paper/viewFile/331/192

Ritchie, H. (2020). *Sector by sector: where do global greenhouse gas emissions come from?*. OurWorldInData. https://ourworldindata.org/ghg-emissions-by-sector

Rudatyo, & Tresya, R. (2021). *Construction of Electric Vehicle Policies in Indonesia , Types , and Prices*. International Conference For Democracy and National Resilience (ICDNR 2021). http://dx.doi.org/10.2991/assehr.k.211221.016

Schröder, M., Iwasaki, F., & Kobayashi, H. (2021). *Promotion of Electromobility in ASEAN: States, Carmakers, and International Production Networks*. Economic Research Institute for ASEAN and East Asia (ERIA). https://www.eria.org/uploads/media/Research-Project-Report/2021-03-Promotion-Electromobility-ASEAN/Promotion-of-Electromobility-in-ASEAN.pdf

SEAI. (2020). *Driving Purchases of Electric Vehicles in Ireland – Behavioural insights for policy series*. Sustainable Energy Authority of Ireland. https://www.seai.ie/publications/Driving-Purchases-of-Electric-Vehicles-in-Ireland.pdf

Setiawan, V. N. (2021). *RI Imports Raw Materials for Electric Batteries Despite Abundance of Nickel, Why?* [RI Impor Bahan Baku Baterai Listrik Meski Nikel Melimpah, Mengapa?] - Pertambangan Katadata.co.id. Katadata. https://katadata.co.id/happyfajrian/berita/61441bcc1ff03/ri-impor-bahan-baku-baterai-listrik-meski-nikel-melimpah-mengapa

Shajedul, I. (2021). Evaluation of Low-Carbon Sustainable Technologies in Agriculture Sector through Grey Ordinal Priority Approach. *International Journal of Grey Systems*, *1*(1), 5-26. https://doi.org/10.52812/ijgs.3

She, Z. Y., Qing Sun, Ma, J. J., & Xie, B. C. (2017). What are the barriers to widespread adoption of battery electric vehicles? A survey of public perception in Tianjin, China. *Transport Policy*, *56*, 29–40. https://doi.org/10.1016/j.tranpol.2017.03.001

Sidabutar, V. T. P. (2020). A study of the development of electric vehicles in Indonesia: prospects and constraints. [Kajian pengembangan kendaraan listrik di Indonesia: prospek dan hambatannya]. *Jurnal Paradigma Ekonomika*, *15*(1), 21–38. https://doi.org/10.22437/paradigma.v15i1.9217

Sierzchula, W., Bakker, S., Maat, K., & Van Wee, B. (2014). The influence of financial incentives and other socio-economic factors on electric vehicle adoption. *Energy Policy*, *68*, 183–194. https://doi.org/10.1016/j.enpol.2014.01.043

Sirait, S. (2020). *7 Factors Challenging the Implementation of Electric Vehicles in Indonesia* [7 Faktor yang Menjadi Tantangan Implementasi Kendaraan Listrik di Indonesia]. Carmudi. https://www.carmudi.co.id/journal/7-faktor-yang-menjadi-tantangan-implementasi-kendaraan-listrik-di-indonesia/

Tarei, P. K., Chand, P., & Gupta, H. (2021). Barriers to the adoption of electric vehicles: Evidence from India. *Journal of Cleaner Production*, *291*, 125847. https://doi.org/10.1016/j.jclepro.2021.125847

Thorn, M. (2021). *Indonesia on Thorny Path to Electric Vehicles*. Jakarta Globe. https://jakartaglobe.id/business/indonesia-on-thorny-path-to-electric-vehicles

Umah, A. (2021, September 21). *This is the reason electric cars are still expensive in Indonesia*. [Ini lho Alasan Mobil Listrik Masih Mahal di RI]. CNBC. https://www.cnbcindonesia.com/news/20210921093008-4-277837/ini-lho-alasan-mobil-listrik-masih-mahal-di-ri

Utami, M. W. Dela, Yuniaristanto, & Sutopo, W. (2020). Adoption Intention Model of Electric Vehicle in Indonesia. *Jurnal Optimasi Sistem Industri*, *19*(1), 70. https://doi.org/10.25077/josi.v19.n1.p70-81.2020

Vassileva, I., & Campillo, J. (2017). Adoption barriers for electric vehicles: Experiences from early adopters in Sweden. *Energy*, *120*, 632–641. https://doi.org/10.1016/j.energy.2016.11.119

Volkswagen. (2019). *How electric car incentives around the world work*. Volkswagen. https://www.volkswagenag.com/en/news/stories/2019/05/how-electric-car-incentives-around-the-world-work.html

Wilberforce W, C. (2021). *Electric vehicles market Intelligence Report*. GreenCape. https://www.readkong.com/page/electric-vehicles-market-intelligence-report-greencape-2289456

World Population Review. (2022). *Greenhouse Gas Emissions by Country 2022*. World Population Review. https://worldpopulationreview.com/country-rankings/greenhouse-gas-emissions-by-country

Yuniza, M. E., Pratama, I. W. B. E., & Ramadhanianti, R. C. (2021). Indonesias incentive policies on electric vehicles: the questionable effort from the government. *International Journal of Energy Economics and Policy*. https://doi.org/OI: https://doi.org/10.32479/ijeep.11453

Zigwheels. (2022). *20 New Electric Cars for Sale March 2022*. Zigwheels. https://www.zigwheels.co.id/en/mobil-baru/elektrik/