Standardization of Plugs and Sockets for Two- and Three-wheeled Electric Vehicles (EVs) in Contributing to the Advancement of the National EV Industry

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Abstract: The Indonesian government has issued Presidential Regulation Number 55 of 2019 focusing on accelerating the battery-based electric motor vehicle program for road transportation, various supporting regulations and standards have been established. However, a crucial aspect that is lacking in this regulation is standard plugs and sockets, especially those intended for two-wheeled and three-wheeled vehicles. To meet the needs of the very large vehicle market in Indonesia. Therefore, this research seeks to develop a standardized plug and socket system for charging electric vehicles, thereby ensuring interoperability between manufacturers. This standard is designed to accommodate fast charging, allowing two-wheeled or three-wheeled vehicles to efficiently utilize public electric vehicle charging infrastructure with fast charging duration. Qualitative descriptive methods were applied in this research. A group discussion forum approach was carried out to collect data to reach agreement to achieve the objectives of the research. The research results include the design of Indonesian National Standards to support production processes in the manufacturing sector, product prototypes, design of test requirements and procedures to support product quality testing. The objectives of this research is to develop a draft Indonesian National Standard to support production processes in the manufacturing sector, product prototypes, design testing requirements and procedures to support product quality testing. This research includes literature study, prototype development, testing, and preparation of standard proposals, with support from related agencies such as the National Research and Innovation Agency of Indonesia, National Standardization Agency of Indonesia, government agencies, related ministries, and related technical committees.

Keywords: standard; plug and socket-outlets; vehicle connector and inlets; electric vehicle; two-wheeled; three-wheeled

1. Introduction

The transition to sustainable and environmentally conscious transportation is a global imperative, and battery-based electric vehicles (BEVs) play a pivotal role in this transformative journey[1–5]. Recognizing the need for a swift and comprehensive shift to electric mobility, Indonesia is poised to embark on an Acceleration Program for BEVs. The government has issued Presidential Regulation Number 55 of 2019 (PERPRES 55/2019) concerning the BEVs[6]. This government program is intended to adopt science and technological innovation related to the development of BEV nationally. Another benefit is that environmental management and community economic growth continue to increase[7–10]. In line with this, the Ministry of Energy and Mineral Resources (ESDM) has issued Ministerial Regulation Number 13 of 2020 concerning Provision of Electrical Energy Charging Infrastructure[11]. The latter regulation focuses on plug and socket standards for four-wheeled electric vehicles. However, it does not address the standards for plug and socket for fast charging of two- or three-wheeled electric vehicles in the same ministerial regulation.

In support of PERPRES Number 55/2019, the Ministry of Industry has also issued several regulations, including Ministerial Regulation Number 27 of 2020, which outlines the roadmap and implementation strategy for the electric vehicle (EV) industry and infrastructure in Indonesia. Fig. 1 shows the implementation targets and development for two and four-wheeled EVs according to this regulation. The target sales volume for two-wheeled EVs appears significantly larger compared to that of four-wheeled EVs, indicating the potential market and industrial support for two-wheeled EVs. With Indonesia ranking as the third-largest user of EVs in the world (with over 130 million units on the road), the penetration of two-wheeled EVs is projected to surpass that of four-wheeled vehicles. In 2025, Indonesia will have a dominant role in the EV industry. It is targeted that by 2025 Indonesia will have 2,100,000 units of two-wheeled electric vehicles and 400,000 types of four-wheeled electric vehicles and others. The government is seeking an electric bus fleet for the metropolitan city of Jakarta of 14,000 electric buses which have been produced to make this program a success[12].

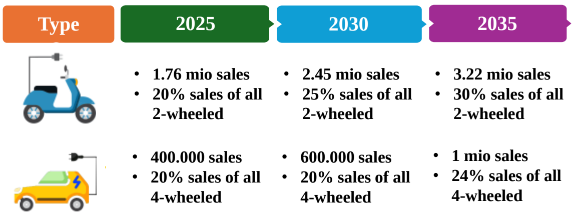
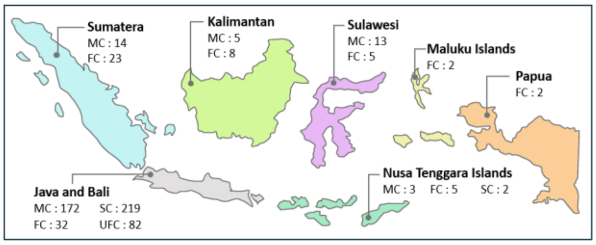


Fig. 1: Target of electric vehicle implementation and development in Indonesia[13].

Fig. 2 presents the development of the number of electric motor vehicles (EMV), both two-wheeled and passenger car four-wheeled vehicles, in Indonesia. By the end of 2022, there were already 42,000 two-wheeled EVs being used across the country. Although there was a 200% significantly increase in the sales of two-wheeled EVs in 2022, it has not yet reached the targeted number (1.76 million by 2025). However, the sales of EV passenger cars experienced a remarkable 564% increase in 2022.

Fig. 2: Growth of EV sales in Indonesia[13,14].

Fig. 2 shows that the number of four-wheeled EVs used as a means of passenger transportation in 2021 will be 1,708 units. Furthermore, it shows the increase in the use of two-wheeled EVs starting in 2019, amounting to 1,248, in 2020 increasing to 3,357, then in 2021 amounting to 13,898 and peaking in 2022 amounting to 42,706. This shows that there is an increase of around 5.5% in the use of EVs every year from 2020 to 2022. This significant increase in sales of passenger car EVs can be attributed to several factors, including the presence of four-wheeled EV manufacturers in Indonesia and the widespread availability of public charging infrastructure[15–17]. Fig. 3 illustrates the number and distribution of public electric vehicle charging stations for four-wheeled vehicles in Indonesia, which categorized into 4 charging modes (slow, medium, fast, ultra-fast). However, none of these modes currently support the charging of two or three-wheeled EVs. Charging stations for two or three-wheeled vehicles are still being built individually and can only cater to specific manufacturers, which restricts their growth and availability.



Note : **MC** : Medium Charging, **SC** : Slow Charging, **FC** : Fast Charging, **UFC** : Ultra-Fast Charging

Fig. 3: Number and distribution of public electric vehicle charging station for four-wheeled EVs in Indonesia[13].

Meanwhile, the National Research and Innovation Agency (BRIN) has conducted research related to the public electric vehicle charging station starting from 2018 until 2023, as shown in Fig. 4.

Throughout the process, the research team has undergone technology transfer and innovation for the components of both the SPKLU and the battery swap station utilizing local manufacturers. One of the key research focuses has been on the development of a fast charger for two-wheeled vehicles, with a power capacity of 1.8 kW and a current of 80A. This SPKLU is equipped with a human machine interface touchscreen and supported by various payment methods, such as smart cards and payment gateways. The product boasts an impressive 73% domestic component and has achieved 7th technology readiness level.

The development of fast charger features is of utmost importance, considering the necessity for quick charging times ranging between 10 minutes to 2 hours (depending on the battery type used), thus reducing queues and reservation waiting times for users. On the other hand, the charging of four-wheeled EMV in Indonesia already adheres to the SNI IEC 62196 standard; an International Electrotechnical Commission (IEC) Standard that is adopted by the National Standard of Indonesia (SNI). Indonesia utilizes the Type 2 (Mennekes) standard for alternating current (AC) charging, whilst the Combined Charging System (CCS)® Type 2 standards and CHAdeMO® for direct current (DC) charging. Table 1 illustrates the standard of the plugs and comparison of their performances (in the most recent technology).

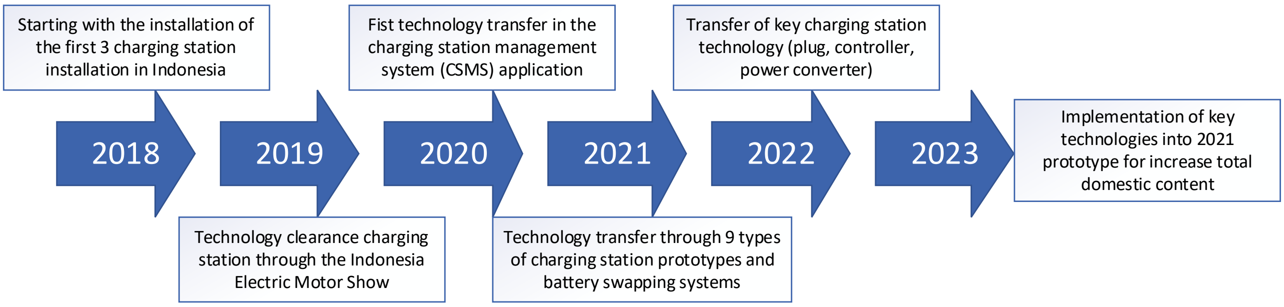


Fig. 4: History of EV infrastructure development activities at BRIN.

Meanwhile, for two or three-wheeled EVs, Indonesia has not yet established a specific plug and socket standard. An example of a plug and socket currently used for charging two-wheeled Evs in Indonesia is the Chogori®/Jnicon® M23 2+1+5 (Fig. 5), which is a standard from China and can be found in electric motorcycle brands like Gesits® and Viar®. This plug consists of 2 power pins, 1 grounding pin, and 5 data pins.

Table 1. Plug standards used in Indonesia and other countries[18,19].

Country	AC	DC
Japan	Type 1 Max V_{AC}: 240 V (single-phase only) Max I_{AC}: 16 A Max P_{AC}: 19.2 kW	CHAdeMO Max V_{DC}: 400 V Max I_{DC}: 400 A Max P_{DC}: 400 kW
USA		CCS 1 Max V_{DC}: 480 V Max I_{DC}: 500 A Max P_{DC}: 360 kW
Europe	Type 2 Max V_{AC}: 400 V (three phase) Max I_{AC}: 32 A Max P_{AC}: 22 kW	CCS 2 Max V_{DC}: 400 V (three-phase) Max I_{DC}: 500 A Max P_{DC}: 360 kW
S. Korea		
Singapore		
China	GB/T Max V_{AC}: 250 V Max I_{AC}: 32 A Max P_{AC}: 7.4 kW	GB/T Max V_{DC}: 440 V Max I_{DC}: 250 A Max P_{DC}: 237.5 kW
Indonesia	Type 2 Max V_{AC}: 400 V (three phase) Max I_{AC}: 32 A Max P_{AC}: 22 kW	CHAdeMO Max V_{DC}: 400 V Max I_{DC}: 400 A Max P_{DC}: 400 kW & CCS 2 Max V_{DC}: 400 V (three-phase) Max I_{DC}: 500 A Max P_{DC}: 360 kW
Thailand		

However, the Chogori®/Jnicon® standard has a limitation in its charging current capacity, as it can only support a current up to 60 A. Consequently, this standard does not allow for fast charging, which requires a current of up to 80 A. In Indonesia, there is still no vehicle which reaches charging capacity 80 A. As the comparison, the data from some electric motorcycle manufacturer is attached in Table 2.

Fig. 5: Chogori®/Jnicon® plug and socket display[1,7].

Table 2. Current rate charging among electric motorcycle manufacturers[20–25].

EV Manufacturers	Max Charging Rate (A)
Gesits®	6.7[a)]
Viar®	5.75[b)]
Alva One®	25[c)]
Polytron®	10.5[d,e)]
United®	7[f)]
Selis®	5.4[g,h)]

Therefore, the objective of this research is to create a draft of the Indonesian National Standard to enhance production processes in the manufacturing sector, including product prototypes, design testing requirements, and procedures for product quality assessment. This research is part of the process of standardizing plugs and sockets for two-wheeled and three-wheeled electric vehicles. That from 2023 until now the process is still ongoing, then the full impact will only be measured in the future. This research encompasses a review of literature, prototype development, testing, and the formulation of standard proposals, with assistance from relevant organizations including the National Research and Innovation Agency of Indonesia, the National Standardization Agency of Indonesia, government bodies, pertinent ministries, and specialized technical committees.

2. Literature Review

Over time, the concern of EV standardization has evolved. Fifteen years ago, the primary issues were related to installing charging infrastructure and demonstrating the readiness to accept incoming EVs[26]. Later, the focus of standardization shifted to fast charging and the power suitability of charging outlets[27]. Then in Germany, a study had been discussing the charging technologies followed by the elaboration of the EV charging standards. A similar discussion to our research can be found in here[28], which provides an overview of the technical design and safety requirements of conductive charging stations and systems, including their infrastructure. However, this research does not detail the standardization process for the design and the safety requirements concerning Swedish standards. Papers focusing on the Indonesian context have primarily discussed the adoption of EVs along with the challenges[29–31], strategies[32–35], and impacts[36–38], but they do not address standardization. Given the importance of standardization, this research explores EVs from a broad perspective, encompassing both technical and standardization aspects.

This research focuses on the standardization of electric plugs and sockets for two-wheeled and three-wheeled EVs in Indonesia today. The development of EVs in Indonesia until the beginning of 2023 will increase rapidly. Following the increase in the use of two-wheeled and three-wheeled EVs, is directly proportional to the need for plugs and sockets for two-wheeled and three-wheeled EVs[14,19]. This means that each two-wheeled and three-wheeled EV requires one pair of plugs and socket when charging the battery on the EV[39,40]. Until 2022, Indonesia does not yet have national standards for plugs and sockets for two-wheeled and three-wheeled EVs. For this reason, it is expected that this research can provide recommendations to the government, especially the relevant Ministries and the National Standardization Agency of Indonesia (BSN) in the context of formulating and accelerating policies related to the standardization of plugs and sockets for this EV type in Indonesia[41].

The foundation of this research is laid upon a comprehensive exploration of existing global standards, emphasizing fast-charging systems designed for electric two and three-wheeled, including relevant IEC standards, as well as other types of plug and socket standards that do not currently have IEC standards. By examining pertinent literature, including international standards, and emerging technologies, we aim to identify gaps and set the groundwork for a standard that aligns with the unique requirements of the Indonesian EV landscape.

Regarding these urgently required for plug and socket standardization, this research provides recommendations for the development of this national standard to the government, related ministries, and the BSN. The urgency for national standards for plugs and sockets for two-wheeled and three-wheeled EVs is one of the main requirements when it comes to the use of this EV type. Bearing in mind that currently in Indonesia the use of two-wheeled and three-wheeled EVs is significantly increase.

2.1 IEC Standards for EV

In a standard development, there is a special institution responsible for developing the standards in supporting the EV industry development, that is the International Electrotechnical Commission (IEC) Technical Committee (TC). One of their TCs which handles the development of IEC standards for Electrical Vehicle; namely TC 69 "Electric Road vehicles and electric industrial trucks". They have published around thirty-eight standards related to electrically powered road vehicles.

Table 3 shows most related standard from the total of 38 IEC standards were found related to the development of the EV industry and its components. Regarding the standards in Table 3, IEC Members, including Indonesia, are eligible to adopt them for the benefit of their respective countries according to their needs. From the total 38 IEC standard, it was found that there are 19 IEC Standards most likely related to plug and socket equipment of EV charging. In this case, for standard plug and socket requirements for electric two-wheeled and three-wheeled vehicles, Indonesia is carrying out an adoption process to IEC Standards as its necessity.

Table 3. IEC Standard in Supporting the Development of Electrical Vehicle.

No.	IEC	Description
1	IEC 60364-7-722	Particular requirements for unique setups or sites for low-voltage electrical systems, particularly those dedicated to providing power for EVs
2	IEC 60786	Requirements for devices designed for managing EVs on roads
3	IEC 61439-5 ed2.0 (2014-08)	Particular requirements for arrangements designed for distributing power in public networks, specifically comprising low-voltage switchgear and controlgear assemblies
4	IEC 61851-1 ed2.0 (2010-11)	General requirements for charging system for EVs using conductive technology
5	IEC 61851-21 ed1.0 (2001-05)	Particular requirements for specifications for connecting EVs to an alternating current/direct current power supply in an EV conductive charging system
6	IEC 61851-21-1 Ed. 1.0	Particular requirements for EMC standards for the onboard charger of EVs when connecting conductively to an a.c./d.c. power supply in an EV conductive charging system
7	IEC 61851-21-2 Ed. 1.0	Particular requirements for EMC standards for EV charging systems located externally (off-board) in the context of conductive charging systems for EVs
8	IEC 61851-22 ed1.0 (2001-05)	Particular requirements for EVs designed for use in an EV conductive charging system that utilizes a.c.
9	IEC 61851-23 ed1.0 (2014-03)	Particular requirements for EVs designed for use in an EV conductive charging system that utilizes d.c.
10	IEC 61851-24 ed1.0 (2014-03)	Particular requirements for digital communication between a d.c. EV and another EV for the control of d.c. charging in an EV conductive charging system.
11	IEC 61851-3-1	General requirements for conductive power supply systems for Light Electric Vehicles (LEVs) utilizing both a.c. and d.c., specifically designed for LEVs within the EVs conductive power supply system
12	IEC 61851-3-2	Particular requirements for offboard conductive power supply systems for LEVs using d.c. within the EVs conductive power supply system
13	IEC 61851-3-3	Particular requirements for battery exchange system designed for LEV within the EVs conductive power supply system
14	IEC 61851-3-4	Particular requirements for communication system specifically for LEV within the EVs conductive power supply system
15	IEC 61980-3	Specific requirements for magnetic field power transfer systems utilized in wireless power transfer (WPT) systems for EVs
16	IEC 62196-1 ed2.0 (2011-10)	General requirements for connectors, outlets, vehicle plugs, and inlets designed specifically for the conductive charging of EVs
17	IEC 62196-2 ed1.0 (2011-10)	Particular requirements for dimensional compatibility and interchangeability of a.c. pins and contact-tube accessories associated with plugs, socket-outlets, vehicle connectors, and vehicle inlets, particularly designed for the conductive charging of EVs
18	IEC 62196-3 ed1.0 (2014-06)	Particular requirements for the dimensional compatibility and interchangeability of d.c. and a.c. pins and contact-tube vehicle couplers used in plugs, socket-outlets, vehicle connectors, and vehicle inlets, particularly designed for the conductive charging of EVs
19	IEC/TR 60784 ed1.0	Requirements for monitoring and control devices for EVs on roads

This development of standardized plug and socket for electric two- or three-wheeled fast charging refers to the following standards:

1) IEC 61851-25:2020, “Part 25: DC EV supply equipment where protection relies on electrical separation”[40]. This standard is relevant to direct current EV supply equipment used for charging the EV in question. The standard applies to systems with a rated supply voltage of up to 480 V alternating current or 600 V direct current. The resulting output voltage does not exceed 120 V direct current and the output current is limited to 100 A direct current. The standard also explains the criteria for EV direct current supply equipment. This ensures electrical separation between the primary and secondary circuits. In addition, it determines the control and communication requirements between the direct current EV supply equipment and the EV.

2) IEC 62196-1:2022, “Part 1: General requirements”[42]. For EV plugs, EV sockets, vehicle connectors, vehicle inlets, and cable assemblies for EVs use these standards. On the other hand, this standard applies to conductive charging systems equipped with control means, and rate

voltage not exceeding:

- 690 V AC 50 Hz to 60 Hz, at a rated current not exceeding 250 A.
- 1,500 V DC at a rated current not exceeding 800 A (IEC), n.d.-c)

3) IEC 62196-6:2022, "Plugs, socket-outlets, vehicle connectors and vehicle inlets – Conductive charging of electric vehicles – Part 6: Dimensional compatibility requirements for DC pin and contact-tube vehicle couplers intended to be used for DC EV supply equipment where protection relies on electrical separation"[41]. This document is applicable to vehicle inlets, connectors, and cable assemblies designed for EVs used in conductive charging systems. For EVs with a conductive charging system, then for vehicle inlets, connectors, and cable assemblies designed using these standards. This accessory is for the direct current interface of charging systems specified in IEC 61851-25:2020. This is intended to support a rated operating voltage of up to 120 V direct current with a rated current of up to 100 A.

4) IEC 60664-1:2020, "Insulation coordination for equipment within low-voltage supply systems – Part 1: Principles, requirements, and tests"[43].

The normative reference in IEC 62196-1:2022 uses this reference standard. In Clause 28 of this standard has specific limitations in the development process, especially for creepage distance, clearance, and solid insulation for equipment based on its performance criteria. Because one of the design literacy goals is to have a smaller perpendicular plug and socket interface. In the development of plug and socket standards, requirements were discovered that limited the distance between electrical power and data pins. This standard has specific limitations in the design development process, particularly for creepage and clearance requirements. One of the design literacy goals in this research was to have smaller perpendicular connectors and socket interfaces. This research found the need to limit the distance between electrical power and data pins.

2.2 International Organization for Standardization (ISO) Of EV Standards

In sub-chapter 2.1 above, it has been explained that the international body responsible for developing standards for EVs, electronics and electronics is the IEC. On the other hand, there is another international body which is responsible for all product standards traded on international or global markets, that is the ISO.

At ISO, the TC which is responsible for developing standards for electrically powered road vehicles is TC 22 Road Vehicle. ISO/TC 22's role in shaping international standards involves focusing on standardization concerning compatibility, interchangeability, and safety. This includes establishing terminology and testing procedures, encompassing instrument characteristics, to assess the function of different categories of road vehicles and their respective gear as outlined in Article 1 of the 1968 Vienna Convention on Road Traffic, under the United Nations' auspices. These vehicles encompass mopeds, motorbikes, motorized vehicles, semi-trailers, trailers, light trailers, articulated vehicles, and combination vehicles. Additionally, ISO/TC 22's Sub Committee (SC) 37 specializes in electrically driven vehicles has established around 22 ISO international standards related to – Electric Energy Vehicles. Some related standards are shown in Table 4.

Table 4 explains the discovery of several ISO Standards supporting the growth of the EV sector in Indonesia and various nations globally. From Table 4, 22 ISO standards were found, however in fact there are only 10 specific ISO Standards related to plugs and sockets for two- or three-wheeled EVs. Regarding its needs, Indonesia as an ISO member can adopt ISO standards for the interests and needs of its national industry.

2.3 SNI in Supporting EV Industry

To strengthen government initiatives aimed at nurturing the domestic EV sector, there's a mandate requiring all EV component products to obtain SNI certification. This directive aligns with Article 19 of PERPRES 55/2019, "the Acceleration Program for Battery-Based EVs on Highways"[44]. This article emphasizes the necessity for product certification and technical standards applicable to companies in the battery based EVs industrial and component sectors[43]. Complementing this regulation, the BSN has, until 2019, established multiple SNIs to bolster this governmental endeavor. In line with the fact that the Government has established and enforced PERPRES 55/2019[44], the BSN has established fourteen SNIs for SPKLU until 2019. To facilitate the trade, to develop the national EV industry and to regulate the use EVs in Indonesia, the BSN has established several SNI, shown in Table 5.

Table 4. International Organization for Standardization (ISO) Standard to supporting Electrical Vehicle Industry in the World.

No.	ISO	Description
1	ISO 6469-1:2009	Particular requirements for safety specifications for on-board rechargeable energy storage systems (RESS) designed for electrically propelled road vehicles
2	ISO 6469-2:2018	Particular requirements for safety specifications for the operational safety of electrically propelled road vehicles
3	ISO 6469-3:2018	Particular requirements for safety specifications pertaining to the electrical safety of electrically propelled road vehicles
4	ISO/TR 8713:2012	Terminology used for vehicles powered by electricity on roads

No.	ISO	Description
5	ISO 8714:2002	Reference energy consumption and range benchmarks for electric road vehicles, focusing on testing protocols for passenger cars and light commercial vehicles
6	ISO 17409:2015	Linkage to an external electric power source for electrically driven road vehicles, with a specific emphasis on safety standards
7	ISO/PAS 19295:2016	Voltage subdivisions within voltage class b for electrically driven road vehicles
8	IEC/ISO 62752:2016	Device for controlling and protecting mode 2 charging of electric road vehicles within the cable (IC-CPD)

Table 5. National Standards of Indonesia (SNI) to Supporting Development for the National Electrical Vehicle Industry.

No	SNI	Description	References	TC
1	SNI IEC 61851-1:2017	General requirements for EV conductive charging system	IEC 61851-1:2017	29-06
2	SNI IEC 61851-21-1:2017	EMC requirements for conductive links to a.c/d.c. power sources for on-board chargers in EV conductive charging systems	IEC 61851-21-1:2017	29-06
3	SNI IEC 61851-23:2014	Particular requirements for d.c. EVs for EV conductive charging systems	IEC 61851-23:2014	29-06
4	SNI IEC 61851-24:2014	Particular requirements for digital communication between a d.c. EV charging station and an EV for control of d.c. charging for EV conductive charging system.	IEC 61851-24:2014	29-06
5	SNI IEC 62196-1:2014	General requirements for connectors, outlets, vehicle ports, and vehicle inlets designed for the conductive charging of EVs	IEC 62196-1:2014	29-08
6	SNI IEC 62196-2:2016	Particular requirements for the compatibility and interchangeability of dimensions for pins and contact tube fittings used in a.c. plugs, receptacles, vehicle connectors, and vehicle inlets for the conductive charging of EVs	IEC 62196-2:2016	29-08
7	SNI IEC 62196-3:2014	the compatibility and interchangeability of dimensions for d.c pins. and a.b./a.s. and a.c./d.c. and vehicle contact tube couplers used in plugs, receptacles, vehicle connectors, and vehicle inlets for the conductive charging of EVs	IEC 62196-3:2014	29-08
8	SNI IEC 62893-1:2017	General requirements for charging cables for EVs with rated voltage up to 0.6 / 1 kV	IEC 62893-1:2017	29-06
9	SNI IEC 62893-2:2017	Test methods for charging cables for EVs with rated voltage up to 0.6 / 1 kV	IEC 62893-2:2017	29-06
10	SNI IEC 62893-3:2017	Particular requirements for cables designed for charging a.b. in accordance with modes 1, 2, and 3 of IEC 61851-1, with a rated voltage up to 450/750 V for charging cables intended for EVs with a rated voltage up to 0.6/1 kV	IEC 62893-3:2017	29-06

Table 5 shows that there are 14 SNIs related to EVs and their Equipment. Of the 14 SNIs in Table 5, there are only 10 SNIs specifically related to plugs and sockets for two-wheeled and three-wheeled EVs.

As a fact from the 3 tables above, it is assumed that the application of standards in the electric vehicle industry in general and for electric two-wheeled and three-wheeled vehicles by industry players is adjusted to the needs and policies of current and future regulators. On the other hand, the international Standardization Bodies (ISO and IEC) are progressing step by step in developing standards for these standard requirements. It is very positive that both ISO and IEC always provide the type and scope of standards that are more advanced than the needs of their respective countries as current members of ISO and IEC. On the other hand, for standard users, both ISO, IEC and SNI can be used according to the needs and uses of two-wheeled and three-wheeled electric vehicle users.

3. Research Methods

Research as the demand for EVs continues to surge, there is an imperative need to establish robust standards for essential components, particularly in the realm of fast charging systems. This method delineates a strategic and comprehensive approach for the development of a standardized plug and socket system tailored explicitly for the fast-charging needs of electric two- or three-wheeled in Indonesia. The following diagram represents the flow of the methodology used in this research in Fig. 6. The methodology used in this research is a descriptive analysis that consists of the following steps:

3.1 Design and Engineering

Building upon the insights garnered from the literature review, the design and engineering phase embarks on the creation of a plug and socket system tailored to the swift charging demands of two or three-wheeled EVs in

Indonesia. Designing the plug and socket for two-wheeled EVs in Indonesia according to agreed-upon specifications and adopting relevant IEC standards. This design will serve as a reference for the standard proposal.

3.2 Prototype Development

Practical validation is pivotal in the standardization process. Prototypes will be developed using advanced manufacturing techniques, such as 3D printing and molding with high-performance materials. These prototypes will serve as tangible models for testing, allowing for real-world validation and refinement of the proposed plug and socket system.

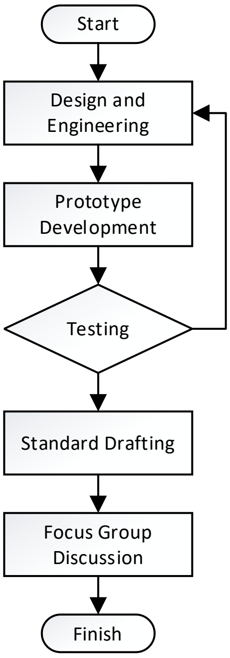


Fig. 6: Research Methodology.

3.3 Testing

Testing several prototype units according to relevant IEC standards (or their modifications). The parameters and results obtained from these tests will be used as references for the standard proposal. Performance, safety, and reliability will undergo meticulous scrutiny, with the outcomes guiding subsequent iterations and optimizations of the plug and socket design. If the prototype does not pass the testing based on the referenced IEC parameters, the next step will return to the design and engineering stage, followed by another round of prototype development. This process will continue to be iterated until the prototype successfully passes the testing.

3.4 Standard Drafting

The culmination of this research involves collaborative endeavors with key stakeholders, including the TC 29-08 on Electrical Accessories and the National Standardization Body. Informed by insights from the literature review, design specifications, and testing outcomes, this research will contribute to the drafting of a comprehensive Indonesian National Standard for plug and socket systems, specifically tailored for the exigencies of fast-charging infrastructure for electric two and three-wheeled.

3.5 Focus Group Discussion (FGD)

FGD associating the BSN, TC 29.08 Electric Vehicle Equipment, the manufacturer one of the commercial companies in Indonesia and electric two-wheeled manufacturers in Indonesia serves several important purposes: alignment with national standards, technical expertise and industry knowledge, manufacturer input and feasibility, industry-specific considerations, regulatory compliance, quality and safety standards, interoperability, and compatibility.

4. Result and Discussion

In its development until early 2023 that some electric motorcycles also use the AC Type 2 plug, like what is used for four-wheeled EVs. However, this plug requires additional equipment in the vehicle, an AC to DC converter for battery charging (on-board charger). The overall weight and dimensions of the electric motorcycle are affected by the weight and the size of the on-board charger. Moreover, the larger size of the plug may not be suitable for small-sized electric motorcycles like scooters, which represent a significant portion of the motorcycle market in Indonesia.

Fig. 7 illustrates the distribution of (conventional) motorcycle sales in the Indonesian market. In Fig. 7, the scooter (scooter Matic) category dominates the domestic distribution with a sales percentage of up to 90.42% on March 2023. Following behind is the under bone, commonly known as “motor bebek” (Indonesian name), with 4.95% of sales, and lastly, the sport category with 4.63%[6,45,46].

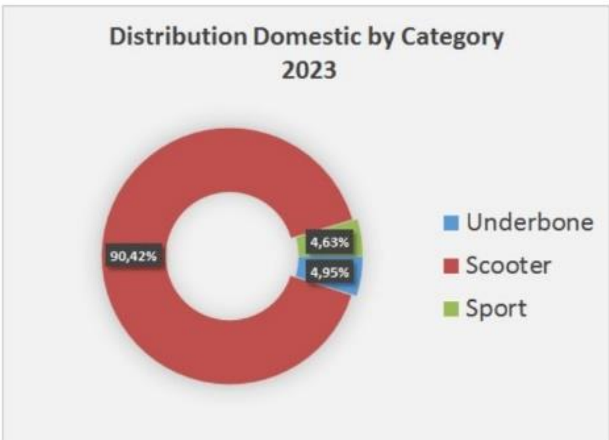


Fig. 7: Current distribution of Indonesia's motorcycle domestic markets by type.

4.1 Design, Engineering and Prototyping

Charging plugs dan sockets for two and three-wheeled electric vehicles that are planned as Indonesian national standards are designed with a shape that has national uniqueness and is inspired by the national symbol of the Pancasila shield. The important thing to consider is the possibility of arcing between two power sockets that refer to the IEC 62196-6 standard as a design guide and the appropriate distance for the DC Power pin by paying attention to clearance and creepage distance. Design is done by iterating to get the most compact design form and in accordance with the standard so as to provide security guarantees. A small and compact charging plug design is needed to be applied to two-wheeled vehicles in Indonesia which have a small size.

Design iterations are carried out as shown in Fig. 8 and prototyping is carried out with additive manufacturing (3D Printing) as an evaluation of the shape of the design results that have been made. Overall, 3 major design iterations were carried out to obtain a small and compact shape and size. In the first design as shown in Fig. 8(a), the dimensions of the face with a width of 51.1 mm and a height of 52.33 mm were obtained and then prototyping with 3D printing was found to be too large to be applied to two-wheeled motorized vehicles in Indonesia. In the second design as shown in Fig. 8(b), the dimensions of the face with a width of 35.9 mm and a height of 37.10 mm are obtained, this design is quite compact and small but the third design iteration is carried out again as shown in Fig. 9(c) to eliminate sharp corners in the design form, the dimensions of the face are obtained with a width of 36 mm and a height of 35.30 after prototyping the design is quite compact and small applied to two-wheeled electric vehicles in Indonesia.

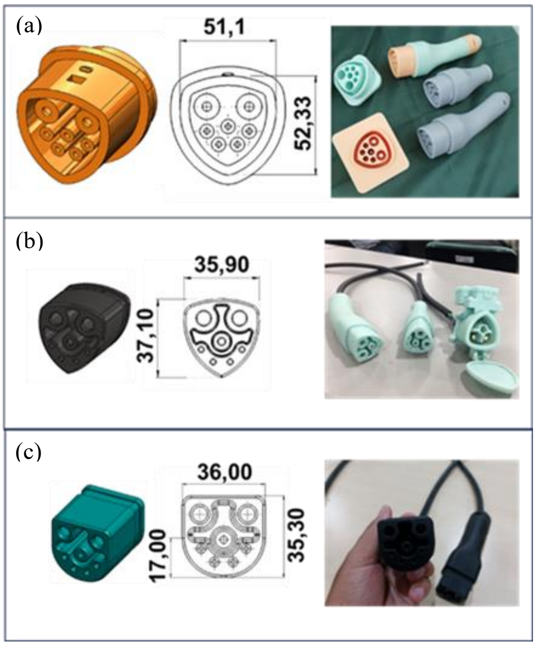


Fig. 8: Design Iteration.

4.2 Academic Paper for National Standard Proposal in Law No. 20, 2014

Starting from the Research Methodology in the sub-chapter above, especially related to activities related to the development and preparation of standardization concepts, especially the development and preparation of the design or concept of SNI which has been carried out by the Research Team. As a follow-up to the development activities of the SNI, the Research Team has succeeded in preparing a design or concept for the SNI in collaboration with the BSN and TC 29.08 "Electric Vehicle Equipment", who's secretariate is located at the ESDM. At the initial stage in conducting research and development of the SNI, the research team referred to IEC 62196-6:2022; with reference to IEC 62196-1:2020 and IEC 61851-25:2020. The evidence of the results of the development and preparation of the SNI design and concept can be seen in Fig. 9 The Draft of National Standards.

The academic paper for an SNI is based on Law Number 20 of 2014 (UU 20/2014), that is "Standardization and Conformity Assessment" and clarified by Government Regulation Number 34 of 2018 (PP 34/2018), that is "the National Standardization and Conformity Assessment System"[34]. It is stipulated that in developing and preparing process of a draft or concept of an SNI, an academic paper is required. The academic paper is based on the results of research or studies that have been carried out.


RSNI1

RSNI1 xxx:202x

Rancangan Standar Nasional Indonesia 1

Steker, stopkontak, konektor kendaraan dan inlet kendaraan
– Pengisian konduktif kendaraan listrik –
Bagian 6: Persyaratan kesesuaian dimensional untuk pin a.s. dan tabung kontak kopler kendaraan dimaksudkan untuk peralatan suplai kendaraan listrik a.s. dengan proteksi bergantung pada pemisahan elektris

Plugs, socket-outlets, vehicle connectors and vehicle inlets –
Conductive charging of electric vehicles –
Part 6: Dimensional compatibility requirements for AS pin and contact-tube vehicle couplers intended to be used for AS EV supply equipment where protection relies on electrical separation

(SNI XXX:2023)

BRIN
BADAN RISET
DAN INOVASI NASIONAL

ICS xxx

Fig. 9: The Draft of National Standards of Indonesia.

The purpose of proposing an Academic Manuscript document is to prove empirically that the proposed SNI Design or Concept has gone through research or study stages that can be proven scientifically and technologically. Furthermore, the objective of proposing the Academic Paper Document is to prove that the Academic Paper Design or Concept for SNI Plugs and Sockets for Two-Wheel and Three-Wheel Electric Vehicles has been carried out in accordance with the principles of science, technological development and innovation following the standards of IEC. This also provides an opportunity if the SNI Design or Concept is designated as SNI then this will make it easier to harmonize the SNI with the IEC standard. Likewise, the 2023 Research Team in proposing the RSNI Plug and Socket Design or Concept for Two-Wheeled and Three-Wheeled Electric Vehicles has gone through research stages which can be proven and explained in the SNI Design or Concept Academic Paper document, Fig. 10.

4.3 National Standard Formulation Program (PNPS)

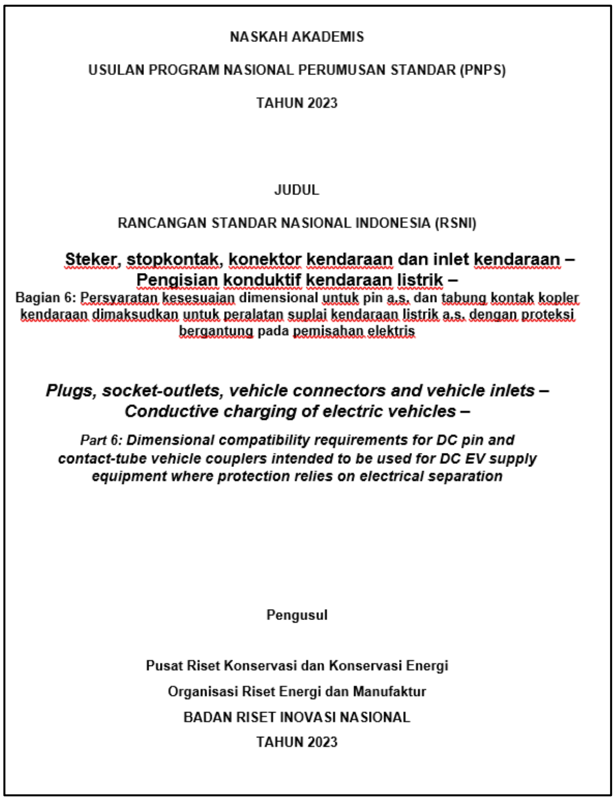
In the mechanism, process, and stages of developing the SNI, there is a stage called the PNPS. The PNPS is a responsibility of the BSN as a Non-Ministerial Government Institution in accordance with Presidential Decree Number 13 of 1997, that is “the National Standardization Agency of Indonesia”[47]. Furthermore, it is strengthened by Law No 20/2014 and Government Policy 34/2018[48], in developing Plug and Socket Standards for Two-Wheeled and Three-Wheeled EVs in 2023 through the proposing stages of the PNPS. In this case, to fulfill the policies that apply in Indonesia and based on the results of science-based research, technological development and innovation, through the Energy Conservation and Conservation Research Center under Organization for Energy and Manufacturing Research (OREM) under The BRIN, is then created research team for Formulating Standards for Plugs and Sockets for Two-Wheel and Three-Wheel EVs to the BSN, starting in September 2023.

Furthermore, the results of the proposed National Program for Formulating Standards by BRIN were accepted by the BSN and will then be determined to be the National Program for Formulating Standards through processes and mechanisms in accordance with Law Number 20 of 2014[46] and Government Regulation Number 34 of 2018[44]. Finally, the BSN agreed that the proposed National Program for Formulating Standards The plugs and sockets for two- and three-wheeled EVs were authorized to be implemented in 2024 in accordance with the BSN policy in coordination with the BRIN.

4.4 Draft of Testing Procedure

The testing of plug products, sockets, vehicle connectors, and vehicle inlets aims to ensure that these products are designed and constructed correctly so that their performance can be relied upon during normal use, minimizing risks to users or the surrounding environment in accordance with established requirements. The technical requirements and testing methods for these products refer to the IEC 62196-1:2022[42] and IEC 62196-6:2022[41].

The refered standards offer comprehensive guidelines to ensure the safety and performance of the EV charging accessories. They consist of 34 clauses outlining general, safety, and performance requirements, along with corresponding testing procedures. For specific tests, such as those for clearance and creepage distance, IEC 62196-1:2022 references detailed standards that set precise procedures and limits. Notably, Clause 28 of IEC 62196-1:2022 addresses creepage distances, clearances, and distances through sealing compounds. It mandates that clearance and creepage distance requirements be assessed according to IEC 60664-1 and IEC 60664-3, which focus on insulation coordination for low-voltage systems.


NASKAH AKADEMIS

USULAN PROGRAM NASIONAL PERUMUSAN STANDAR (PNPS)

TAHUN 2023

JUDUL

RANCANGAN STANDAR NASIONAL INDONESIA (RSNI)

Steker, stopkontak, konektor kendaraan dan inlet kendaraan – Pengisian konduktif kendaraan listrik –
Bagian 6: Persyaratan kesesuaian dimensional untuk pin a.s. dan tabung kontak kopler kendaraan dimaksudkan untuk peralatan suplai kendaraan listrik a.s. dengan proteksi bergantung pada pemisahan elektris

Plugs, socket-outlets, vehicle connectors and vehicle inlets – Conductive charging of electric vehicles –
Part 6: Dimensional compatibility requirements for DC pin and contact-tube vehicle couplers intended to be used for DC EV supply equipment where protection relies on electrical separation

Pengusul

Pusat Riset Konservasi dan Konservasi Energi
Organisasi Riset Energi dan Manufaktur
BADAN RISET INOVASI NASIONAL
TAHUN 2023

Fig. 10: Academic Paper Document of National Standard Proposal[15].

The type of testing referred to in this document is type testing. If a part of an accessory has previously passed testing at a certain compliance level, relevant type testing does not need to be repeated if the compliance level is not higher specified in this document. Product samples are tested as they are and under normal usage conditions, at ambient temperature (20 ± 5)°C and at a frequency of 50 Hz unless otherwise specified. The products covered in this document are intended for use with EV supply equipment for direct current (DC) that meets the requirements of IEC 61851-25[40]. Specific product testing refers to IEC 62196-6:2022[41] by applying the relevant clauses within the general requirements of IEC 62196-1:2022[42]. According to this standard, the testing requirements starting from the supply ratings, connections between the power supply and EV, accessories, marking, dimensions, product protection against electric shocks, earthing, until the contact endurance test.

5. Conclusion

This study has outlined the problematic conditions about the highly variation of plug and socket and the growth of two- and three-wheeled EV. This issue made the government's intention in accelerating EV usage become challenging. Hence, it is essential to undertake efforts to address this situation. Therefore, this research has developed a specific plug and socket for two- and three-wheeled EV, as well as its SNI draft. Moreover, an academic paper including a set of testing procedures of the SNI draft has been submitted as a PNPS to the BSN.

After conducting results and discussions, several recommendations can be formulated which will become important materials for the government and stakeholders related to the development of Plug and Socket for Two- and Three-Wheeled EV Standards. The important recommendations from this research are:

1. The relevant Ministry's policy should regard to the SNI for Plug and Socket for Two- and Three- Wheeled EV to strengthen the implementation of the SNI.
2. The BSN should formulate the SNI of Plug and Socket for Two- and Three- Wheeled EV to support the PERPRES 55/2019 in regards of the IEC Standard of Plug and Socket for Two- and Three-Wheeled EV.
3. Relevant stakeholders and users of two-wheeled and three-wheeled EVs are encouraged to use the SNI, both in the production process and the trade of Two- and three-wheeled for electrical vehicles.

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