

Development of the PCX ELECTRIC

Makoto MITSUKAWA¹
Yasushi TAKAHASHI¹

Hiroki ICHIKAWA¹
Nobuo SHIGEMIZU²

Katsuyuki OKUBO¹
Katsunori OKUBO²

Takaaki KATO¹

ABSTRACT

We developed the electric motorcycle model “PCX ELECTRIC” that satisfies usability under the traffic environment in Japan and ASEAN’s motorcycle sales major countries. The PCX ELECTRIC features easily removable battery packs, which practically helps eliminate the waiting time associated with charging the battery. The compactly designed EV system, which is efficiently packaged in the vehicle, uses two removable 48 V battery packs connected in series to realize a 96 V system suitable for driving the electric motorcycle. The EV system mounted on the body of the 2018 PCX achieves a motor power of 4.2 kW, top speed of 60 km/h, and cruising range of 41 km (at a steady 60 km/h).

In addition, we developed a highly-convenient battery attaching system that enables fixing of the battery to the vehicle body and engaging of the connectors with a single action operation.

1. Introduction

In order to reduce CO₂ emissions intensity in products by 30% from compared with 2000 levels by 2020, Honda has been focusing on developing more electric vehicles as a means to achieve this goal.

As regards electric motorcycles specifically, in 1994, Honda developed and marketed the “CUV-ES⁽¹⁾” for use by government agencies and local municipalities. Then, in 2010, we also marketed the “EV-neo^{(2), (3)}” for use mainly by delivery businesses, targeting the Japanese market for small motorcycles, i.e., Class I motorcycles that have a displacement of up to 50 cc or rated power of up to 0.6 kW. Through these efforts, we have identified some issues inherent to electric motorcycles, such as long charging time and insufficient cruising range.

To overcome these issues, we have developed the “PCX ELECTRIC” to offer an unprecedented electric motorcycle experience to people around the world. As a concrete mean, we developed and employed a removable battery system to not only reduce charging waiting time, but also to increase the cruising range. Figure 1 shows an image of the developed PCX ELECTRIC model.

This paper introduces the new technologies used in the PCX ELECTRIC.



Fig. 1 The PCX ELECTRIC

2. Aim of Development

2.1. Development Concept

We defined the development concept as “e-Comfort Saloon for Enhanced EV Experience.” Comfort Saloon is a concept that the base model 2018 PCX⁽⁴⁾ inherited from the

¹ Motorcycle R&D Center

² R&D Center X

original model. That means that it is a model with a sense of higher quality. The attraction of the electric motorcycle is also added to the development concept of this model. This expresses our wish to offer many customers wonderful experience of PCX ELECTRIC.

The earlier EV models, the CUV-ES and EV-neo, were marketed only in Japan. However, we observed that interest in reducing CO₂ emissions is increasing not only in developed nations such as Japan, but also in developing countries.

We therefore decided to market the new PCX ELECTRIC not only in Japan, but also in three ASEAN countries, i.e., Thailand, Vietnam, and Indonesia.

However, the 50 cc (0.6 kW) class motorcycles that are specific to Japan have not been marketed in these ASEAN countries. Rather, there is a popular market demand for mainly 125 cc models, which are equivalent to Japanese Class II motorcycles of up to 125 cc or rated power of up to 1.0 kW. Accordingly, we aimed to achieve a motor power that would enable the riders in these countries to travel easily and safely among other Class II equivalent motorcycles and automobiles and to provide a cruising range sufficient for daily use.

2.2. Removable Battery System

The two previous EV models use a built-in battery system where the batteries are fixed in the vehicle. In the case of the EV-neo that is used for delivery services, we initially assumed that the battery could be recharged before it is fully discharged during the standby time between delivery jobs. We therefore provided both normal and quick chargers for such businesses so that they could choose to employ either one according to their specific needs and service conditions.

However, it is not easy for delivery business operators to predetermine their vehicle operating hours, especially in the case of food delivery services. Such businesses must quickly respond to delivery requests even when the vehicle's battery is being charged and thus the amount of charge can be insufficient for such operations. We also presumed that this issue could also arise in the vehicle models intended for general users.

So, for the PCX ELECTRIC, we decided to employ a removable battery system (instead of a quick charger) to allow the use of fully charged standby batteries to thereby practically help eliminate the waiting time associated with charging the battery.

Another advantage of using a removable battery system is that you can more freely choose the charging location. Once the battery is detached from the vehicle, you can charge it almost anywhere that has a charging point with a special charger. So, even if no power source is available near the vehicle parking spot, such as in a parking area of an apartment house or condominium, you can use such a vehicle without having to face the issue of installing a power supply system.

In fact, Honda exhibited a prototype removable battery at the Tokyo Motor Show 2015 (TMS 2015) to demonstrate that the concept could be applied to various Honda products in the future, as shown in Fig. 2.

Therefore, based on this concept, we defined the basic specifications for the removable battery by also considering its possible future application in handy batteries and other general-purpose energy products in addition to its mobile use in small motorcycles or ultra-compact four-wheel EVs as follows:

- (1) Volume: about 7 liters (to take into account the limited installation space of small motorcycles)
- (2) Capacity: 20.8 Ah
- (3) Power: 2.5 kW, continuously for 10 minutes or longer (to consider sufficient hill-climbing performance for small motorcycles)
- (4) Voltage: 50.4 V (to satisfy the safe low-voltage requirement defined in UNR 136)

Based on the above basic specifications, we continued our research to further define detailed specifications with the aim of moving toward achieving the goal of “practically zero waiting time and practical cruising range.”

2.3. Power Performance

In order to increase the power of electric motorcycles, a larger motor, a larger battery for the power source, and a larger power control unit (PCU) for motor control are required. The issue is that this directly leads to a heavier vehicle weight and a higher sale price.

Also, as the basic battery specifications have already been defined, we need to use multiple battery packs to increase the power. For this reason, the PCX ELECTRIC adopted a solution that uses two battery packs connected in series to increase the voltage to reduce the discharge current, and help avoid the use of large-diameter wires at the same time.

In this way, we successfully achieved a maximum motor power of 4.2 kW, as described later in the paper. On the assumption that this solution would be utilized in our model design, we further researched the power performance requirements for the EV model by taking into consideration the usability required in the target markets.

To begin with, to understand the running speed



Fig. 2 “Honda Smart Mobility City” at TMS 2015

distribution of small motorcycles in urban areas, we conducted a survey to measure the running speed of manual transmission motorcycles and CVT scooters in Bangkok in Thailand, Hanoi in Vietnam, and Jakarta in Indonesia. The resulting running speed distributions are shown in Fig. 3.

Although we observed some differences between countries, we found that for approximately 60% to 70% of the time the running speed ranged from 20 to 50 km/h and that for more than 90% of the time the running speed was 60 km/h or less.

Based on this survey result, we decided that, as our power performance goal, the vehicle should be able to run at a speed of at least 60 km/h.

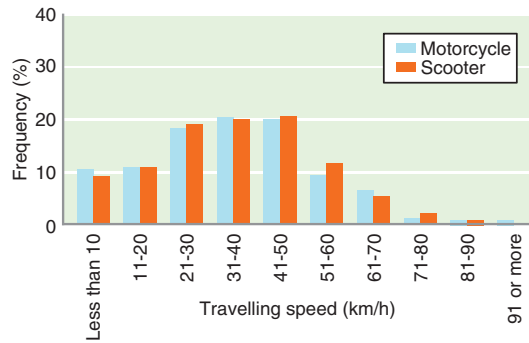
2.4. Cruising Range

Each country has its own standard for how to indicate the cruising range of electric motorcycles in catalogs and other

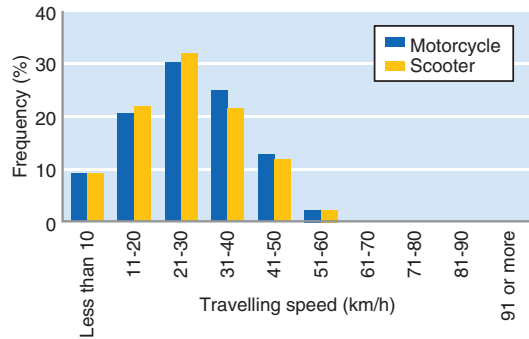
publications. While the cruising range of Class I motorcycles in Japan is indicated for a steady 30 km/h run, the actual cruising range performance deviates significantly from such measurements as it largely depends on how the vehicle is used. This is because the power consumption rate is significantly affected by the pattern of repetitive acceleration and deceleration, in contrast to a steady-speed run. Therefore, we decided to set a target using WMTC mode, which is one of the emission measurement modes used for vehicles with internal combustion engines, as the condition for measuring the cruising range, because it includes more practical acceleration and deceleration scenarios.

Similarly to the case of power performance, we conducted a survey in the three cities by interviewing users about their daily running distance. Figure 4 shows the resulting distributions of daily running distance.

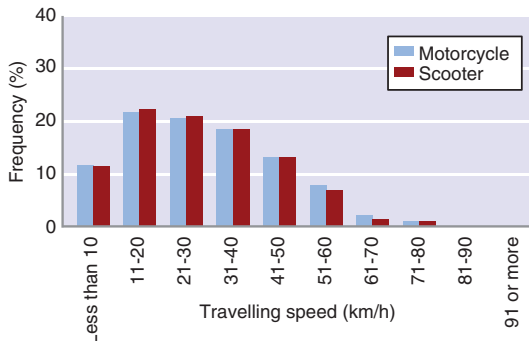
Despite some differences between countries, we can see



(a) Thailand (Bangkok)

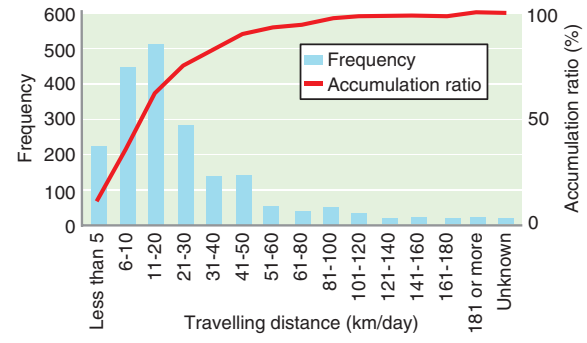


(b) Vietnam (Hanoi)

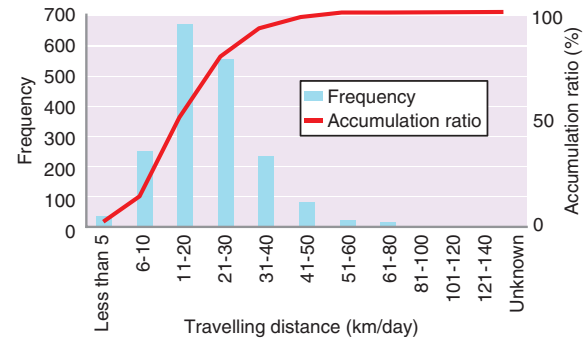


(c) Indonesia (Jakarta)

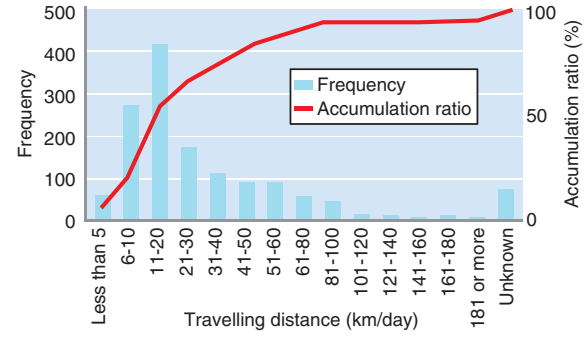
Fig. 3 Distribution of running speed in three countries



(a) Thailand (Bangkok)



(b) Vietnam (Hanoi)



(c) Indonesia (Jakarta)

Fig. 4 Daily running distance in three countries

that 80% or more users in each country have a daily running distance of 50 km/day. Therefore, we targeted a cruising range of 50 km or more after a full charge, assuming internal test criteria equivalent to the corresponding WMTC mode.

2.5. Vehicle Packaging

On the assumption that a global model would be marketed in the three ASEAN countries and Japan, and also taking into account future local assembly operations in these countries, we selected the 2018 PCX⁽⁴⁾ as the base model.

As a scooter of its class, the PCX model is highly supported worldwide, especially in Japan and Southeast Asia, due to its compactness and easy handling, comfortable riding position, sense of higher quality, and the fun riding experience.

We therefore believed that a PCX model with an electric power unit would make a superb electric motorcycle that would be well supported by many people around the world. Accordingly, we aimed to make the EV system as compact

as possible for installation in the existing gasoline engine-based model with minimum modifications. Figure 5 shows the layout of the major EV components.

This approach not only helped to make the system compact, it also helped to prevent a cost increase due to the inclusion of additional miscellaneous parts other than the essential EV components that needed to be newly developed.

In order to provide opportunities to contact electric motorcycles more widely, we examined vehicle specifications from the viewpoint of what should be a model suitable for small commuter users in Japan and ASEAN countries. As a result, we set the aim as a completed vehicle as follows.

To innovate in order to differentiate the EV from engine-based models:

- Newly developed EV system
- Styling items specific to the EV

To provide convenience through simple and user-friendly operation:

- Enjoyable run in a mixed urban traffic
- Simple operation

To incorporate functionality in order to provide a sense of security:

- Sufficient cruising range to cover one day's running distance
- Removable and portable battery packs
- Onboard charger for on-the-spot charging.

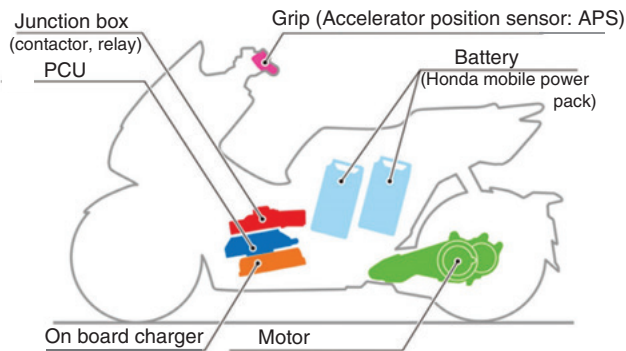


Fig. 5 Layout of EV components

3. EV System

3.1. System Overview

Figure 6 shows a block diagram of the EV system. We designed the EV system to offer the same operability as that

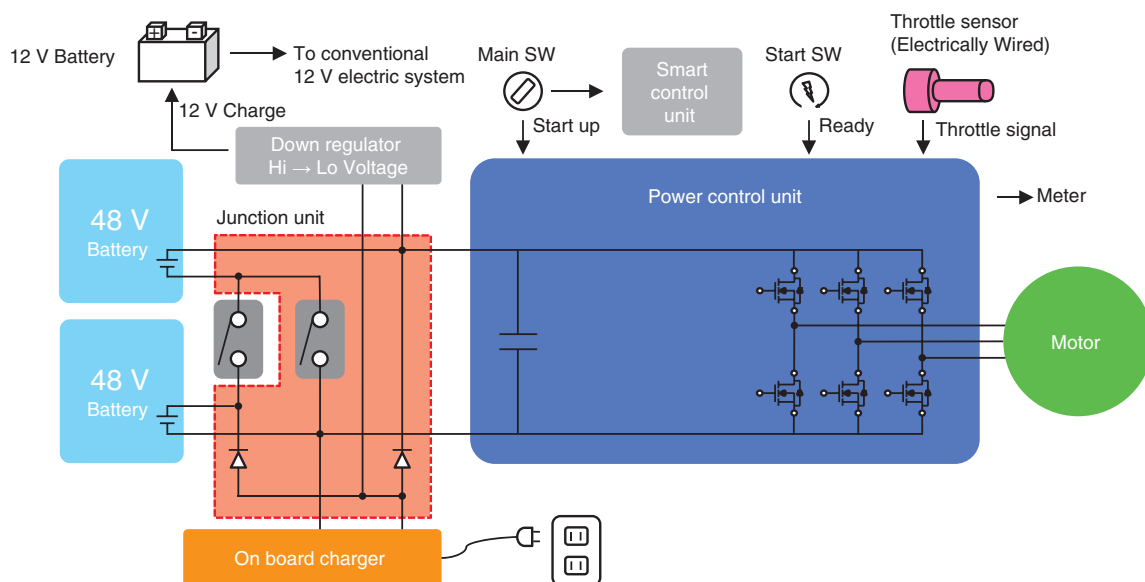


Fig. 6 EV system diagram

of the gasoline engine models, including the use of a main switch to activate the system and a handlebar accelerator grip.

The EV system has two different startup sequences for the run and battery charge modes that are detailed in the following paragraphs. Figure 7 shows a comparison of the two startup sequences. The startup sequence for the run mode is as follows:

(1) Startup of PCU and meter unit

When the user turns on the main switch, a 12 V battery voltage is applied to the PCU and meter unit.

(2) Startup of BMU and communication

The PCU starts up the 48 V battery management unit (BMU) to initiate communication between various components of the EV system. Figure 8 shows the CAN bus line used for information exchange between the EV components.

(3) System standby

The PCU checks for any malfunctions in the components listed in Table 1 and then puts the high-voltage system into its standby state (for details, see Section 3.2. “PCU”).

(4) Start running

Pressing the start switch makes the system ready to run. Then, the user can ride the vehicle using the grip control.

The startup sequence for the onboard battery charge mode is as follows:

(1) Startup of PCU and meter unit

Connecting the charge plug to an outlet (100 - 250 VAC) starts up the PCU and meter unit.

(2) Startup of BMU and communication

Same as in the run mode.

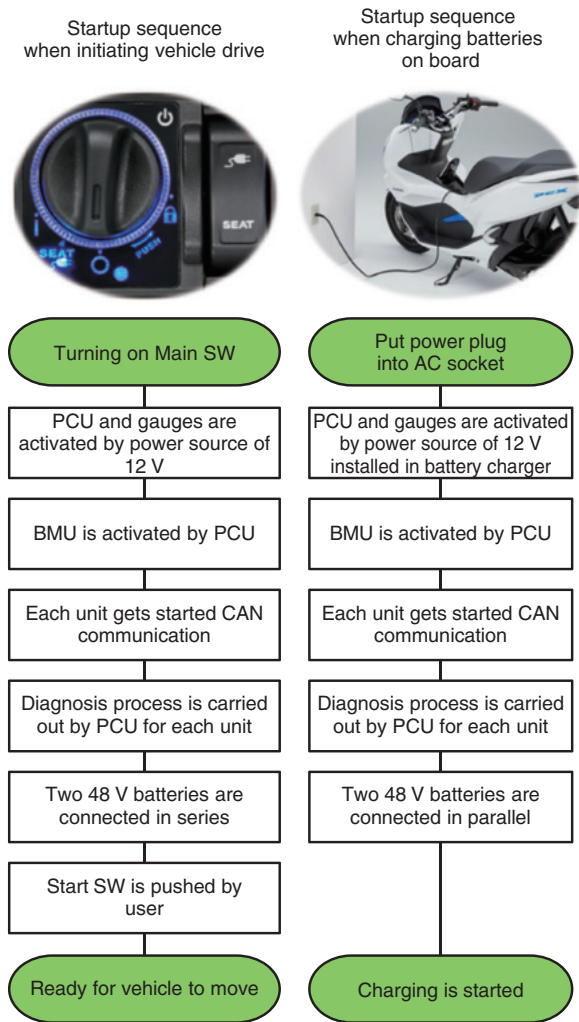
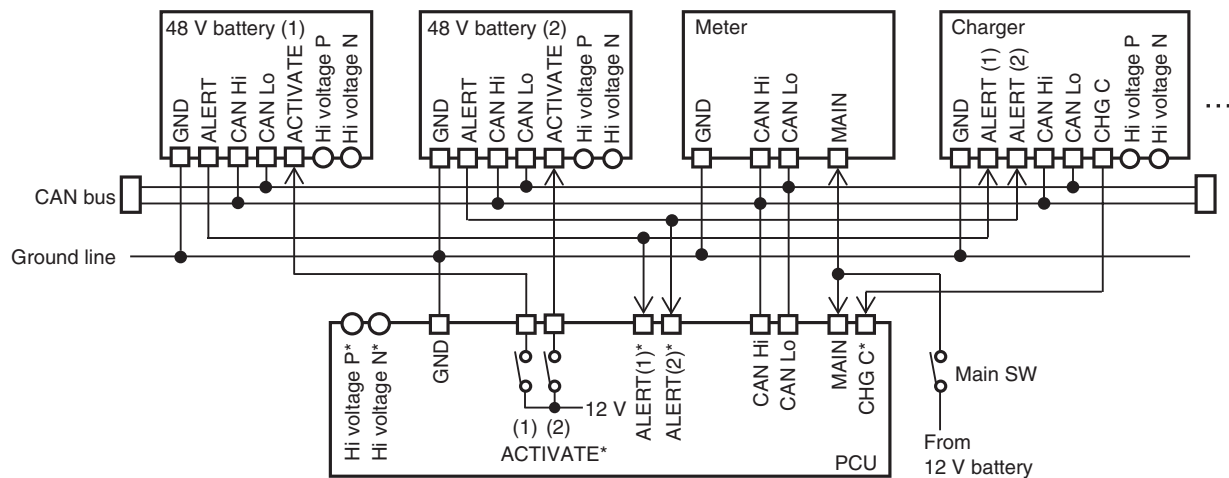


Fig. 7 Comparison of startup sequences



* Details

ACTIVATE: 12 V startup to battery from PCU

ALERT(1)/(2): Detect Battery(1)/(2) connection

CHG C: 12 V startup to PCU from charger

Hi Voltage P/N: Hi voltage positive/negative (connection not shown)

Fig. 8 CAN bus and 12 V system

Table 1 Malfunction detection during run and charge startup sequences

Subjects of monitoring	When initializing for vehicle running	When initializing for charging
Throttle sensor malfunction	✓	
Functional flaws of PCU	✓	✓
Malfunctions of motor sensors	✓	
Functional or communication flaws of charger		✓
Unusual conditions of 48 V batteries	✓	✓
Malfunctions of junction unit	✓	✓
Unusual conditions of down regulator	✓	

✓: to be checked

(3) System standby

The PCU checks for any malfunctions in the components listed in Table 1 and then puts the high-voltage system into its standby state (for details, see Section 3.2. “PCU”).

(4) Start charging

Charging of the two 48 V batteries connected in parallel commences.

As mentioned above, the system uses 48 V batteries to supply the drive power, while the PCU controls the entire power system of the vehicle in the run and charge modes.

3.2. PCU

The following paragraphs give the details of the PCU functions.

In run mode, the PCU controls the main contactor to series-connect the two 48 V batteries to provide a system voltage of 96 V, as shown in Fig. 9. As this system can reduce the drive current compared to a 48 V system of the same power, it has the following advantages:

- The power loss in the high-voltage cable that connects the battery to the PCU is reduced by about 60%, contributing to the overall efficiency of the system.
- The cross-section of the cable is reduced by about 25%, contributing to weight and space reduction.

When charging from an external power source, the PCU controls the relays to connect the two batteries in parallel to set up the 48 V system voltage, as shown in Fig. 10. In this way, uniform charging is made possible even when the remaining charge in the two batteries differs.

Although two batteries of the same specification are

used as previously mentioned, it is necessary to individually monitor the condition of each battery, e.g., remaining charge and temperature, in order to properly adjust the motor power.

For this, the PCU assigns a CAN ID to each battery during the vehicle startup sequence to enable identification of the data transmitted from each battery. Figure 11 provides the flow chart of battery ID assignment.

Thus, the PCU continuously monitors the status of each component and controls the motor power, provides vehicle safety controls, and sends information to meter unit, thereby providing centralized control of the entire vehicle system.

3.3. Motor

In order to enhance the efficiency of the motor over a wide rotation range, we used an interior permanent magnet (IPM) structure consisting of both magnetic torque and reluctance torque. This is because very high performance is required of the motor of the PCX as compared to the motor of the EV-neo which has the same rotor-stator configuration,

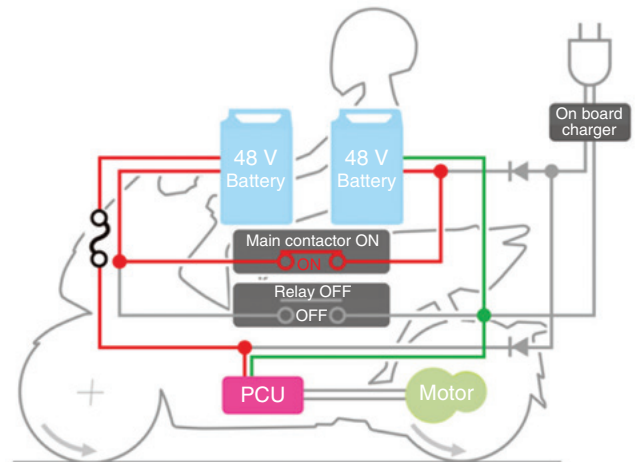


Fig. 9 Diagram of 96 V system

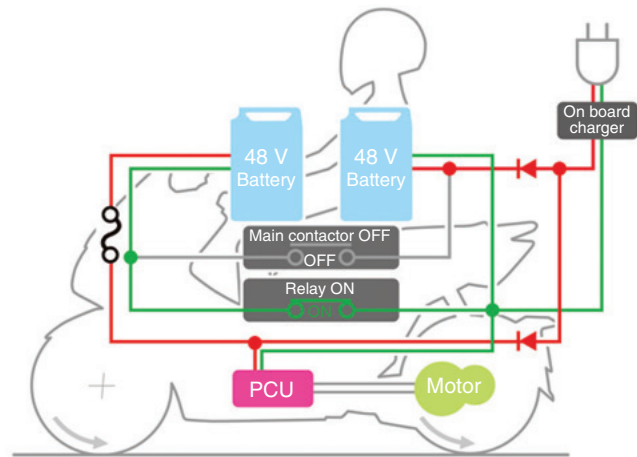


Fig. 10 Diagram of 48 V system

Table 2 Comparison of motor specifications

	EV-neo	PCX ELECTRIC
Rated power (kW)	0.58	0.98
Maximum power (kW)	2.8	4.2
Maximum torque (Nm)	11	18

as show in Table 2. We enhanced the performance by changing the stator coil diameter, number of coil turns, and core thickness and by using the new battery system described later in the paper in order to achieve a maximum motor power of 4.2 kW.

In general, high-power motors require a proper cooling system that consists of additional components such as an oil

pump, radiator, clutch, and so on. However, as our aim was to realize a compact and lightweight motor for this model, we managed at a system without such a motor cooling system, as shown in Fig. 12.

As shown in Fig. 13, a motor torque of 18 Nm is assumed for the low rotation range to help ensure sufficient startup acceleration and hill-climbing power. As the phase current is generally proportional to the torque, a very high phase current delivered during a low-rotation run or prolonged motor stalling can excessively raise the motor temperature and result in damage to the motor.

To help prevent this, we used a thermistor at the stator's coil end to enable the PCU to sense the coil temperature and reduce the output power when the temperature exceeds a threshold, as the first-stage protection. Then, if the coil temperature further increases, the PCU cuts off the power as the second-stage protection.

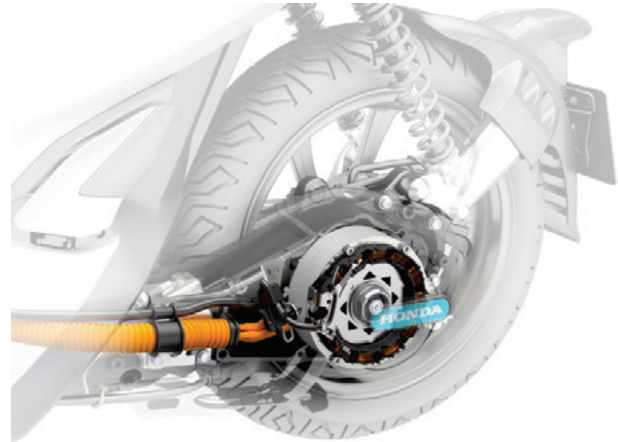


Fig. 12 Motor structure

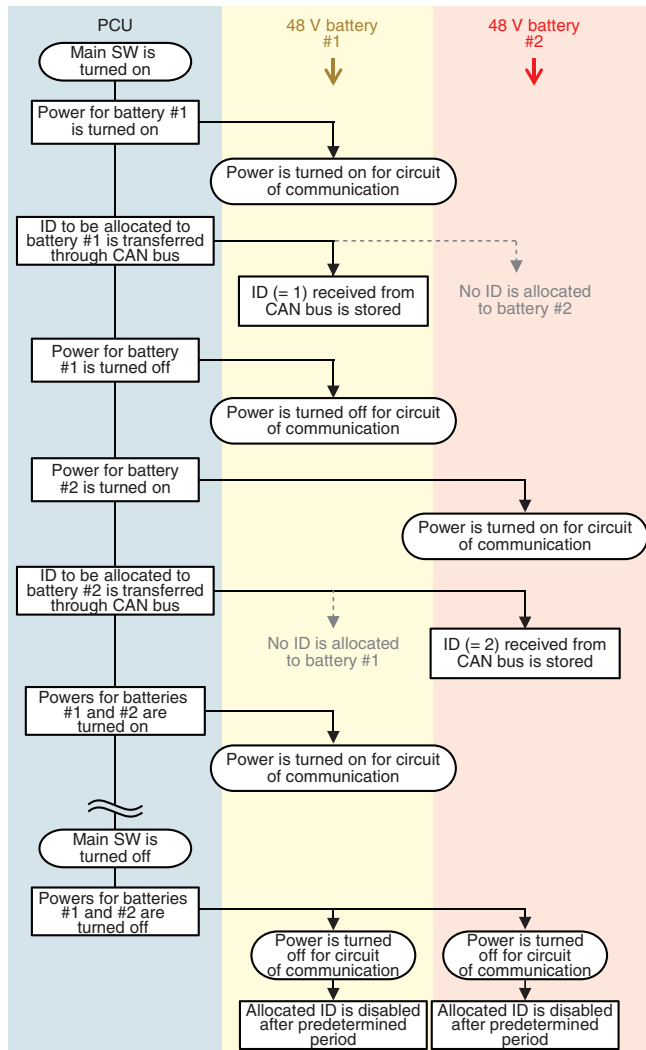


Fig. 11 Flow chart of battery ID assignment

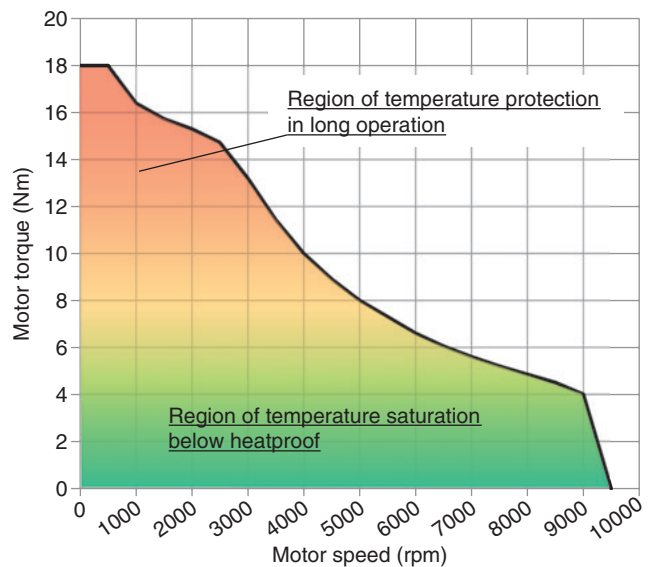


Fig. 13 Torque characteristics of motor

For this, we used a simple bolt-on structure to secure the thermistor for easy maintenance. As shown in Fig. 14, the flat spring structure of the thermistor stay presses the temperature sensing point of the thermistor against the motor coil to realize reliable temperature sensing.

3.4. Battery

We developed a new removable battery “Honda Mobile Power Pack™” which is compact, robust, and stylish as well (Fig. 15). Table 3 provides the basic specifications for

Table 3 Basic specifications of removable battery

Voltage	50.4 V
Capacity	1,052 Wh Min
Volume	7.1 L
Outside dimension (H × W × D)	296 mm × 178 mm × 155 mm
Weight	10.9 kg Max

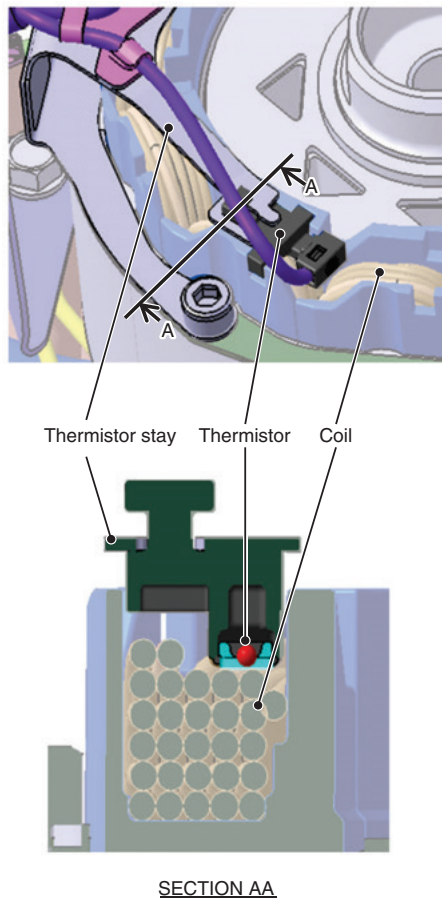


Fig. 14 Motor thermistor structure



Fig. 15 Honda Mobile Power Pack™

the removable battery.

As shown in Fig. 16, we tripled both the volumetric energy density and gravimetric energy density of the battery of the EV-neo through the efficient layout of the cells, battery connector, BMU, and other components. In this way, we realized a compact battery size for easy accommodation in the body of the PCX EV. For a smart appearance without exposed nuts and bolts, we used a three-piece structure consisting of an aluminum extrusion housing and top/bottom covers. In addition, for convenient hand-carrying of the batteries, we added a T-shaped handle to allow the unit to be held in a variety of ways, as shown in Fig. 17.

The connector is required to pass a large current while withstanding frequent engagement and disengagement operations. To satisfy these tough requirements, we newly developed a multiple-contact connector that can allow self-adjustment of the contact pressure, mating position, and insertion angle, as shown in Fig. 18. This connector showed stable electric characteristics even after exceeding the engage/disengage test of 10,000 cycles defined in IEC 62196, which specifies the requirements for battery-charging connectors of electric vehicles, giving it a high durability compared to that of typical connectors of the

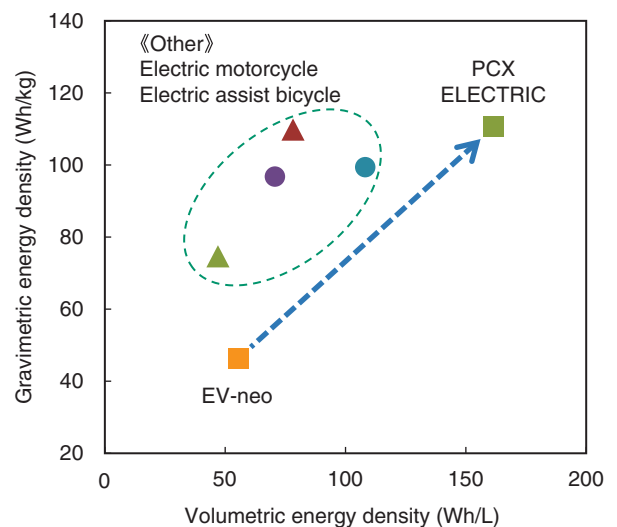


Fig. 16 Comparison of energy densities

same shape. We also achieved a connector current-carrying capacity of 50 A.

Furthermore, due to the nature of portable batteries, a waterproof, anti-drop housing was also required for the battery unit itself.

Therefore, we provided a waterproof structure inside the housing so as not to lose waterproofness even if the housing were damaged and, in order to protect the battery from the shock of being dropped, we applied the measures described in the following paragraphs.

To reduce the shock on the internal battery cells and BMU substrate that could be received through the external housing, we used a shock-absorbing structure inside the battery pack. To help avoid the addition of separate shock-absorbing devices that would make the unit less compact, we used a shock-absorbing structure that had slits in the



Fig. 17 Methods of hand-carrying battery

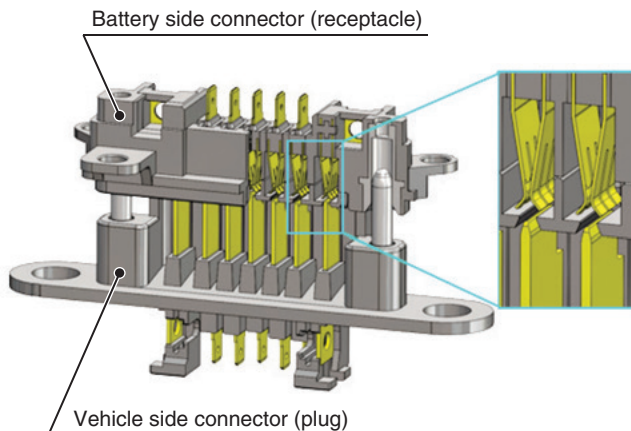


Fig. 18 Internal structure of connector

outer shell of the cell holder of each lithium ion cell, as shown in Fig. 19(a). It was also important to help prevent any internal resonance due to vibration during running. However, the issue is that shock absorption and avoidance of resonance are mutually contradictory. To address this issue, we used a CAE analysis to determine the shock absorption characteristics due to slit deformation and the results of actual vibration/resonance tests to derive the spring characteristics (spring constant) that could satisfy both the shock absorption and resonance avoidance requirements. Accordingly, we realized the desired spring characteristics by properly setting the width and spacing of the slits. Figure 19(b) shows an example of the CAE analysis of the slit deformation. As a result, in the 1 m drop test prescribed in UN R 136 Part 2, no fire or smoke was generated, so that safety could be secured and durability against running vibration was realized at the same time.

As it is not easy for a compact portable battery to have a built-in cooling system, e.g., forced air cooling, self-heating due to charging and discharging would be issues. For this, we optimized the cell layout, the positioning of thermal conductive sheets, and the amount of potting to realize highly efficient heat dissipation through the aluminum housing. Through these efforts, we realized a natural air cooling system that can allow a power output of 2.5 kW for a continuous 10 minutes at an ambient temperature of 40 °C, as shown in Fig. 20.

An additional and significant benefit of this cooling system is the extended service life of the battery, in terms of charge/discharge cycles, due to the reduced cell temperature.

3.5. Battery Attaching Mechanism

The battery attaching mechanism must have functions to secure the battery in place and to help ensure reliable mating of the connectors. These two functions are detailed below.

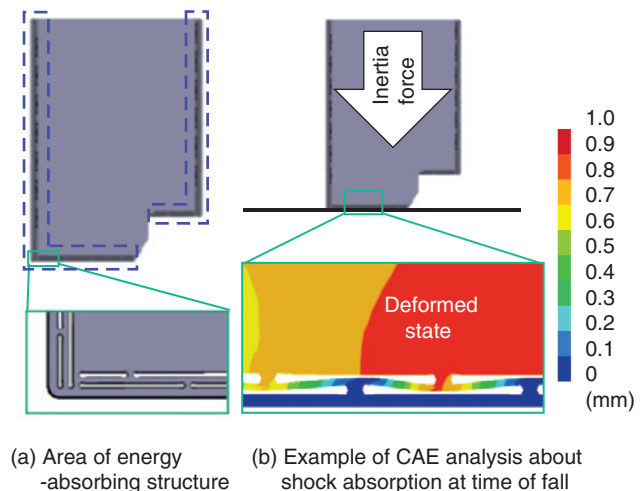


Fig. 19 Shock-absorbing structure for battery

3.5.1. Securing the battery on the vehicle

Figures 21 and 22 show the battery attaching components and their principles of operation. When the user rotates the lock plate around its pivot, the interlocking battery holder also rotates and presses down the battery to secure it in place.

To help prevent the lock plate from being rotated back by the force on the battery due to vibration during running, we set both pivot axes at right angles to each other and made a flat contact surface between the lock plate and

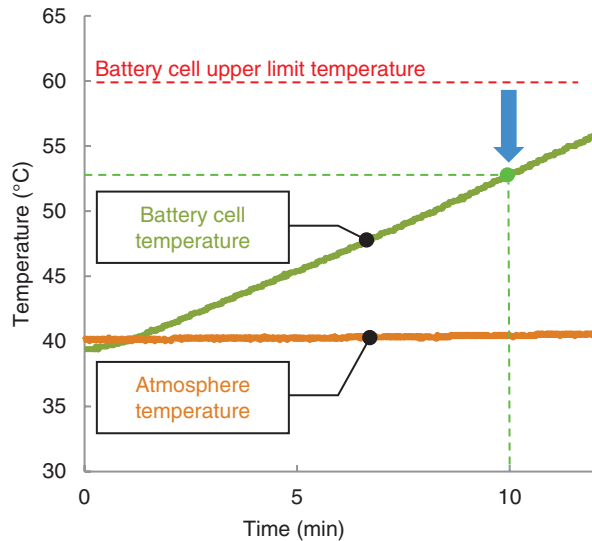


Fig. 20 Temperature of battery cell at 2.5 kW discharge for 10 min

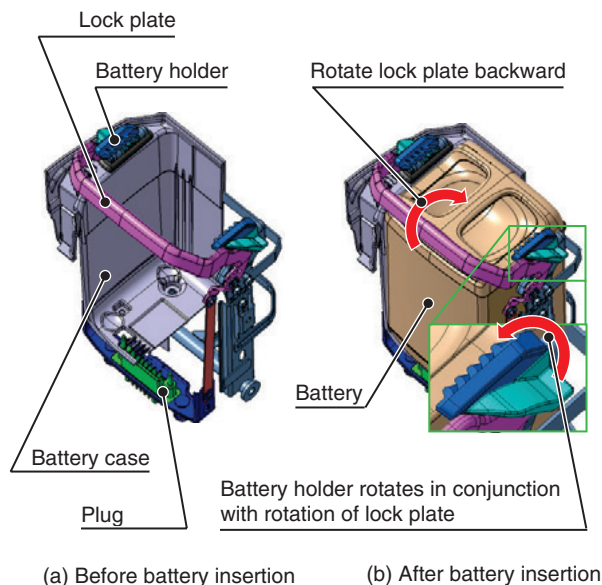


Fig. 21 Structure and operating principle of battery attaching system

battery holder when the battery is secured in place, as shown in Fig. 23.

3.5.2. Connector engagement

Figure 18 shows how the battery connector (receptacle) is mated with the connector (plug) on the vehicle. In order to help prevent the load when inserting the battery from being applied to the plug and the receptacle, the plug is disposed below the bottom of the battery box. Consequently, no mating action can take place when the battery is inserted.

When the lock plate is rotated, the interlocked plug holder moves up to engage the plug and receptacle for the first time as shown in Fig. 24. The plug is float-mounted onto the plug holder via springs to absorb positional errors due to the mechanical allowances of various components, as shown in Fig. 25. In addition, as the springs will always press the plug onto the receptacle, a reliable connection is maintained during running.

With the mechanism described above, we successfully implemented a single-action operation of the lock plate to secure the battery in place with the battery holder and reliably mate the connectors by raising the plug holder at

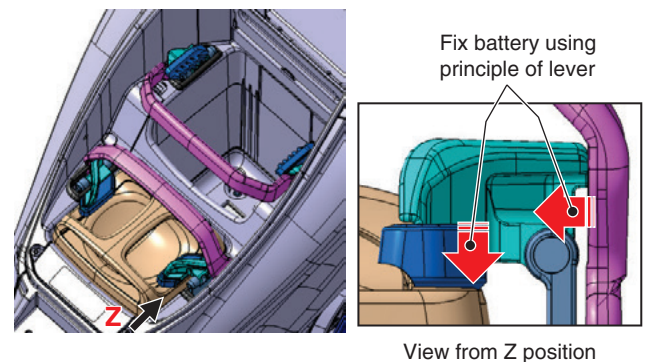


Fig. 22 Operation of lock plate to secure battery in holder

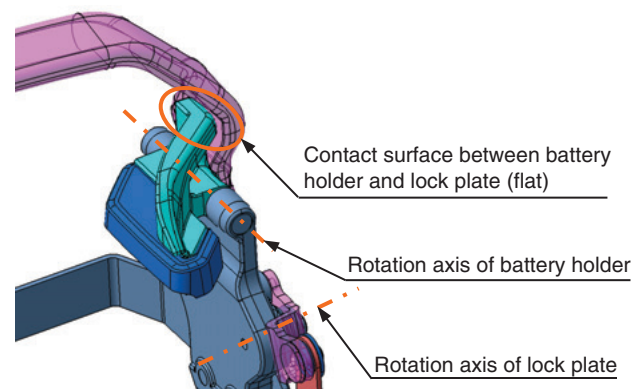


Fig. 23 Battery holder and lock plate pivoting axes and their contact surface

the same time. We also added under-seat stoppers to help prevent the lock plates from being disengaged while the seat is closed. These stoppers provide added reliability in securing the batteries in place and in constantly mating the connectors as shown in Fig. 26.

3.6. Charging System

We provided two methods for charging the batteries.

The first method involves charging the batteries while they are mounted on the vehicle by connecting the AC cable contained in the body to an external power source, as previously mentioned. Using this method, it takes about six hours to fully charge the two batteries connected in parallel.

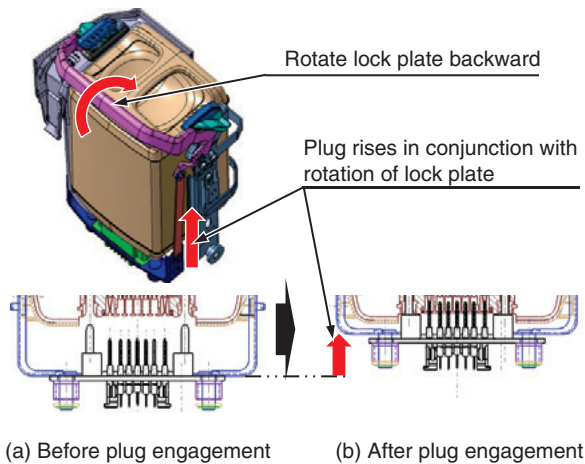


Fig. 24 Connector engaging operation

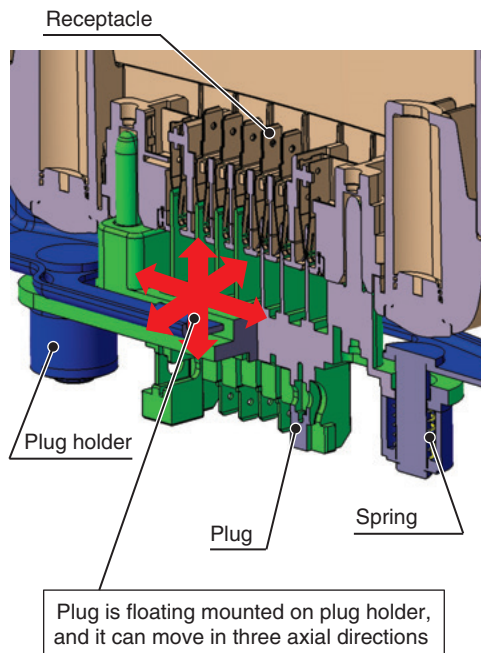


Fig. 25 Floating mount system of plug

The charging status can be checked with the indicator of the meter unit.

The second method involves charging the batteries after removing them from the vehicle. In this case, the removed batteries are connected to the special charger shown in Fig. 27, which is connected to an external power source. This method takes about four hours to fully charge a battery. Charging status can be checked with the special charger indicator. To help prevent unwanted loading on the plug and receptacle during insertion of the battery into the special charger, we used a movable bottom plate supported by oil dampers. As these oil dampers allow the inserted battery to slowly descend to the bottom, the plug and receptacle can be engaged without being subjected to excessive force, as shown in Fig. 28. Similar to the onboard connector mating mechanism, the plug of the special charger is float-mounted.

By providing the above two charging methods, we enabled users to freely choose either method according to their lifestyle, i.e., onboard charging using an outdoor AC

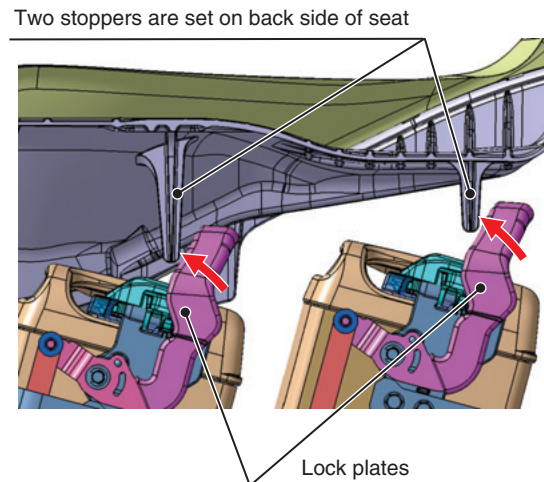


Fig. 26 Under-seat stoppers of lock plates



Fig. 27 Special charger for Honda Mobile Power Pack™

outlet, if available, or indoor charging of batteries removed from the vehicle.

3.7. Vehicle Packaging

By implementing a compact EV system, we were able to integrate the system in an equivalent body size to that of the PCX gasoline-based model to provide a comfortable, high-quality ride.

3.7.1. Dimensions and riding position

In order to retain the comfortable riding position of the existing PCX models, we used the same body cover and seat, placing the two batteries in tandem under the seat and installing the battery removal mechanism in the vehicle frame. In addition, to help ensure that there would be enough space between the rear battery and swinging rear wheel, we increased the wheelbase by 65 mm compared to that of the gasoline-based PCX model. Despite this modification, we only increased the overall vehicle length by 35 mm because we specially designed an unsprung rear fender for better handling in push-walking and for running the motorcycle in urban areas. Table 4 provides the main specifications of the PCX ELECTRIC.

3.7.2. Frame and power unit hanger

In order to use the frame manufacturing facility for

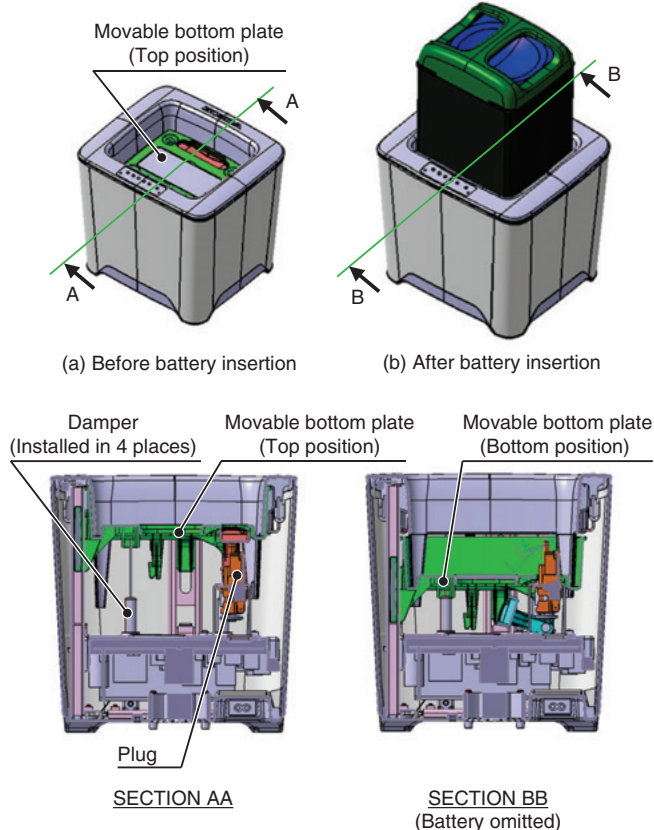


Fig. 28 Structure of special charger

Table 4 Specifications for PCX ELECTRIC

Dimensions L x W x H (m)		1.960 x 0.740 x 1.095
Wheelbase (m)		1.380
Ground clearance (m)		0.132
Seat height (m)		0.760
Vehicle curb mass (kg)		144
Rated power (kW)		0.98
Maximum power (kW/rpm)		4.2/5,500
Maximum torque (Nm/rpm)		18/500
Cruising range at 60 km/h (km)		41
Main battery	Type	Lithium ion
	Battery (V) / (Ah)	50.4 V / 20.8 Ah x 2
Tire size	Front	100/80-14M/C 48P
	Rear	120/70-14M/C 55P

the PCX for the PCX ELECTRIC as well, we retained the positions of the pivot on the frame, bottom of the head pipe, and rear suspension mount to maintain the basic structure. Also, as it was also our intention to maintain the same handling performance despite the 65 mm extension of the wheelbase and weight increase of 13 kg, we specially designed the power unit hanger shown in Fig. 29 from which to suspend the minimized-size power unit. For this, we also used rubber bushings for the fore and aft mounts to absorb inputs from the road surface. In addition, we further optimized the rigidity of the frame and setting of the front and rear suspensions in order to offer high-quality riding comfort by making the most of the inherently low-vibration EV power unit and the excellent handling performance that is equivalent to that of the PCX. Above all, we were able to achieve a maximum speed of 60 km/h and cruising ranges of 57 km (according to an internal test equivalent to the WMTC mode) and 41 km (at a steady 60 km/h).

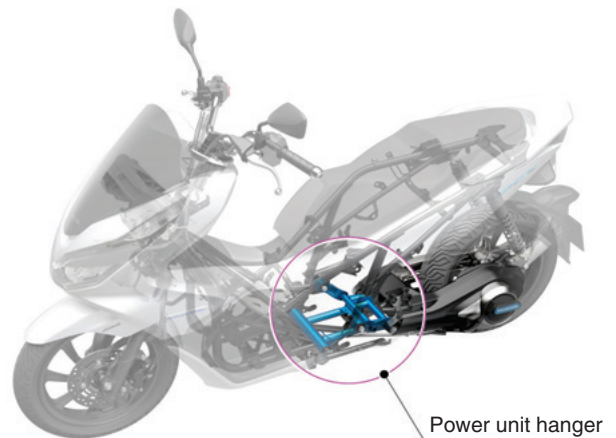


Fig. 29 Power unit hanger

4. Styling Design

4.1. Styling

We retained the styling of the 2018 PCX and PCX 150. Accordingly, based on the styling concept “beautiful and powerful,” we took the main body color portion as a single large form and incorporated tension and softness into it to represent high quality and innovation, as shown in Fig. 30.

In addition, in order to add a unique feature to the PCX ELECTRIC, we applied a special design around the power unit, as shown in Fig. 31.

The round-shaped motor cover, which was designed to symbolize and stress the presence of the electric motor, together with the special plastic rear fender supported by aluminum parts mounted on the unsprung portion emphasize the specialness of the EV among the other PCX series models.

4.2. Color

In order to represent the cleanness and specialness of the EV, we selected pearl white as a special coloring and candy blue as an accent color.

4.2.1. Lamps

The headlight (Fig. 32) and tail lamp (Fig. 33) are the same as the ones used for the PCX HYBRID. However, we used a blue color for the bracket on the back side of the signature lights for the headlight and for the inner lens



Fig. 30 Side view



Fig. 31 External view of power unit

of the stop lamp in order to show the blue color when the lamps are turned off.

4.2.2. Emblem

We used candy blue for the PCX emblem to be recognized immediately as the Honda EV, as shown in Fig. 34. We also used an exclusive emblem for ELECTRIC, as shown in Fig. 35.



Fig. 32 Headlight



Fig. 33 Tail light



Fig. 34 Emblem of PCX



Fig. 35 ELECTRIC exclusive emblem

5. Summary

We developed the electric motorcycle model “PCX ELECTRIC” with the aim of offering better usability in urban areas of Japan and three ASEAN countries, i.e., Thailand, Vietnam, and Indonesia.

By using a removable battery system, we practically helped to eliminate the traditional issue of the waiting time associated with charging the battery. Also, by using a 96 V EV power system to connect two 48 V battery packs in series, we achieved a maximum speed of 60 km/h and a cruising range of 57 km (according to an internal test equivalent to the WMTC mode) and 41 km (at a steady 60 km/h). Through these efforts, we were able to develop an advanced electric motorcycle for Japan and ASEAN countries that meets UNR 136.

Lastly, we would like to mention that the PCX ELECTRIC will be used in various field trials in Indonesia and other countries. We will also continue our efforts to verify the concept in order to move toward a world that can “generate, connect, and use”⁽⁵⁾ electricity through the use of the Honda Mobile Power Pack™.

References

- (1) Nakazawa, Y., Kumagai, C.: Development of Electric Scooter for Practical Use, HONDA R&D Technical Review Vol. 6, p. 17-23
- (2) Cho, T., Honda, K., Mimura, M.: Development of EV-neo, Electrical Motorcycle for Business Applications, Honda R&D Technical Review, Vol. 23, No.2, p. 13-21
- (3) Kobayashi, N.: Development of Electric Motor for EV-neo, Electrical Motorcycle for Business Use, Honda R&D Technical Review, Vol. 24, No.1, p. 29-36
- (4) Omori, J., Shokaku, I., Takayama, K.: Development of 2018 PCX and PCX HYBRID models, Honda R&D Technical Review, Vol. 31, No. 1, p. 41-48
- (5) https://www.honda.co.jp/smartcommunity/ceatec2017/pdf/mobilepowerpack_en.pdf

■ Author



Makoto MITSUKAWA



Hiroki ICHIKAWA



Katsuyuki OKUBO



Takaaki KATO



Yasushi TAKAHASHI



Nobuo SHIGEMIZU



Katsunori OKUBO