

## Introduction of Products

### Electric Mini Excavator PC30E-5

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*Based on the hybrid construction machinery and battery-powered forklift technologies we have manufactured to date, we have developed the new electric (battery-powered) mini excavator PC30E-5, which has achieved ZERO emissions and significant less noise while maintaining an equivalent digging performance to the internal combustion mini excavators. We are ahead of our competitors in introducing it to the market. This paper introduces its main features.*

**Key Words:** PC30E-5, Electric (battery-powered) mini excavator, Noise, Quick charging, CHAdeMO, KOMTRAX, Environment, Safety, Information and communication technology (ICT), Zero emissions

## 1. Introduction

In recent years, climate change is worsening at a rapid rate and the increasing frequency of abnormal weather is negatively affecting the lives of humans globally. As such, it is necessary to make great strides toward a decarbonized society.

With the spread of electric and hybrid automobiles remarkable, the need for electrification is increasing also for construction machinery.



Fig. 1 PC30E-5 (from the catalog)

Table1 Main specifications

Item	Unit	PC30E-5
Overall length	mm	4,950
Overall width	mm	1,740
Overall height	mm	2,580
Machine mass	kg	4,730
Tail swing radius	mm	1,420
Motor output	kW	18.2
Battery capacity	kWh	36

## 2. Aims of development and means of achievement

Mini excavators are often used in urban areas or indoors, where issues regarding work space environment and noise towards the surroundings are common.

The new electric mini excavator, PC30E-5 is advantageous to customers as a result of its “zero emissions” and “reduced noise” in addition to “responding to global warming.”

The outline and features are described below.

### (1) Environment

- ZERO exhaust gas
- Significant reduction of noise for the operator and the surroundings
- Reduction of waste heat

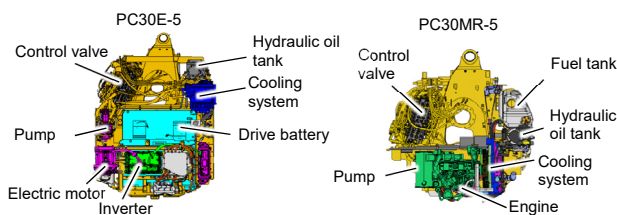
- (2) Performance
  - Performance comparable to internal combustion mini excavators
  - Two types of charging methods available to suit the worksite
    - 1) Normal charger
    - 2) Quick charger
- (3) Safety
  - Highly reliable high-voltage conversion component
  - Double monitoring of charging plugs
  - Compliant with ROPS and OPG Top Guard Level I standards
  - Motor-in-operation beacon lamp
  - Safety equipment equivalent to the PC30/35MR-5
- (4) Maintainability
  - Complete separation of high-voltage section
  - Significant reduction in daily inspections and periodic maintenance
  - Easy maintenance battery
- (5) ICT & KOMTRAX
  - 3.5-inch high-definition liquid crystal display (LCD) monitor
  - Remote monitoring of the daily battery status by KOMTRAX

### 3. Major features

The PC30E-5 design is based on the internal combustion mini excavator PC30MR-5, with the engine replaced by an electric motor and with the fuel replaced by an easy maintenance battery.

Equipped with the same configuration of the hydraulic system as the conventional model, the operation and performance are comparable to conventional machines.

Battery charging can be performed by any individual. No special skills or instruction are required.

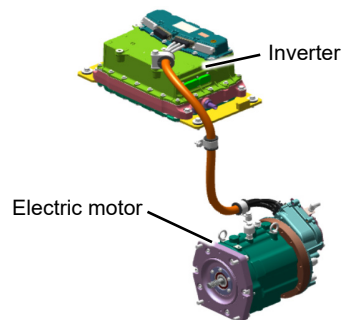


**Fig. 2** PC30E-5 and PC30MR-5 system configurations

### 3.1 Environment

The internal combustion mini excavator uses a fossil-fuel powered engine to drive the hydraulic pump. However, the PC30E-5 is driven by a permanent magnet motor, which has been developed based on the swing motor of our hybrid excavator.

This motor controls its rotation speed and torque using an inverter that converts the battery power. Like the electric motor the inverter was developed in-house by applying the hybrid excavator technology.



**Fig. 3** Inverter and electric motor

#### 3.1.1 ZERO exhaust gas

Completely free of worksite-generated emissions, the PC30E-5 realized a clean working environment.

**Table 2** Exhaust gas comparison (from the sales manual)

Item	PC30E-5	PC30MR-5
Regulations (output classification)	-	Tier 3 emission regulation (8 - 19 kW) by the Japanese Ministry of Land, Infrastructure and Transport
NOx (nitrogen oxide) NMHC (non-methane hydrocarbons)	0	7.5 (NOx + NMHC)
CO (carbon monoxide)	0	5.0
PM (particulate matter)	0	0.4
Diesel black smoke	0	40%

CO<sub>2</sub> emission amount: Reduced by 40% (calculated using the emission factor in 2020)

#### 3.1.2 Significant reduction of noise for the operator and the surroundings

Engine has been the major source of the noise with the internal combustion mini excavator. By replacing the engine with an electric motor, the noise was overwhelmingly reduced.

The noise levels by the battery-powered PC30E-5 were significantly reduced by 6 dB or greater as compared to an internal combustion mini excavator.

### 3.1.3 Reduction of waste heat

Since the PC30E-5 does not have an internal combustion engine, which is the maximum heat source of the conventional model, the operator’s seat is more comfortable than that of the conventional model. Additionally, the temperature of the surrounding area is reduced improving the overall environment.

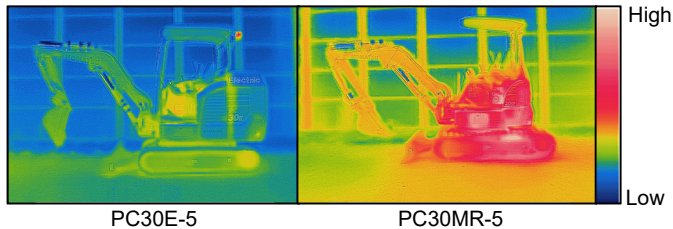


Fig. 4 Waste heat comparison (from the catalog)

## 3.2 Performance

### 3.2.1 Performance comparable to internal combustion mini excavators

The same hydraulic system as that of the internal combustion mini excavator is driven by an electric motor instead of an engine. As for the control system, the internal combustion mini excavator performs pump control and engine control with the machine body controller and the engine controller. For the PC30E-5, an electric controller that controls the high-voltage system and an inverter controller that controls the electric motor, instead of the engine controller, are provided to achieve the equivalent performance.

Although the PC30E-5 is an electric mini excavator, the operator does not require any special skills or knowledge to operate the machine.

In addition, the following functions allow the mini excavator to operate with the added benefit of a reduction in power consumption.

- (1) Work Mode Selection: allows the operator to select between higher productivity and longer operating time, depending on the work circumstance;
- (2) Auto-Deceleration: automatically reduces the rotation speed of the electric motor when the work equipment control lever is in neutral; and
- (3) Auto Idle Shutdown: Stops the electric motor automatically when the machine has been idling with the lock lever locked for a preset amount of time.

### 3.2.2 Two types of charging methods available to suit the worksite

Both “normal” and “quick” charging methods are available for the PC30E-5. The normal charge is designed for use overnight or during long storage. The quick charge will recover up to 80% of the battery capacity in a short time period, such as during a lunch break at a worksite with longer operating hours.

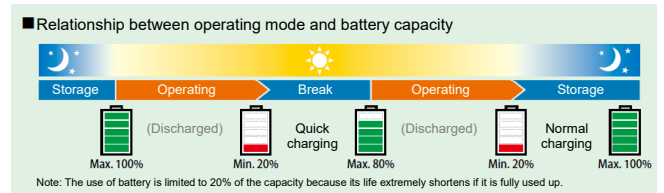


Fig. 5 Charging pattern (from the catalog)

Normal charging employs a 200 V domestic single-phase power supply using the on-board normal charger. For quick charging, the CHAdeMO \* method, which is common for electric automobiles, is employed.

Both normal and quick charging are performed using the same operation commonly used for charging electric automobiles. While monitoring the battery temperature, voltage, and current, the electric controller switches between constant power charging and multi-step constant current charging to extend battery life.

\* : CHAdeMO is a registered trademark of CHAdeMO Association.

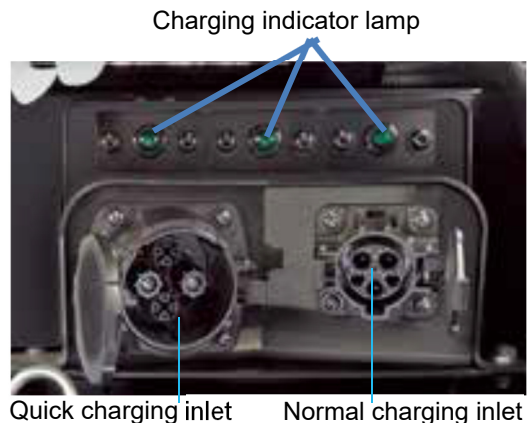


Fig. 6 Charging inlets (from the catalog)

#### (1) Normal charger

The on-board normal charger can charge a battery from a domestic power supply (the patent for performing safe charge control is pending). It enables constant current and constant power charging.

This charger has a two-stage configuration of a power factor correction circuit designed in-house and a DC-DC converter and is also compliant with the European EMC standard of EN61204-3.

The power factor correction circuit makes the normal charger compliant with the harmonic immunity regulations, and the DC-DC converter enables current and voltage control over the wide voltage range of the battery.

In addition, by adopting feed-forward control, this charger achieved high robustness against grid power abnormalities.

#### (2) Optional portable quick charger

A portable quick charger is prepared so that it can be charged at the worksite.



Fig. 7 Portable quick charger

### 3.3 Safety

#### 3.3.1 Highly reliable power delivery unit

The newly developed in-house high-voltage power delivery unit operates safely under the harsh environmental conditions endured by construction machinery that required resistance to vibration and waterproof, and so on.

This unit has a built-in converter for electrical components, a high-voltage control circuit as well as the above mentioned normal charger.

This converter for electrical components charge a battery for electrical components.

The high-voltage control circuit has a mechanism that distributes the battery power to the inverter to control the electric motor during operation. It shuts the motor off during charging to prevent the motor from driving thereby ensuring the safety of the operator and surrounding environment.

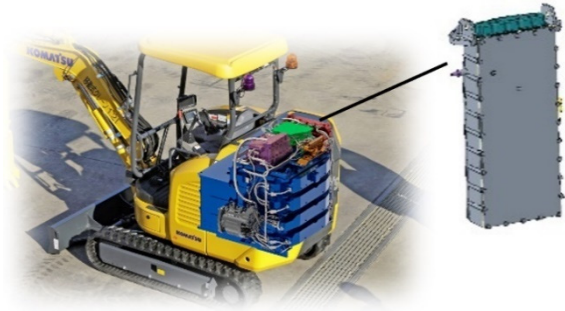


Fig. 8 Power delivery unit

#### 3.3.2 Double monitoring of charging plugs

Both quick charging and normal charging are designed to monitor the connection status of the charging plugs. The PC30E-5 monitors the status using the electric controller and the inverter controller. Safety is assured by ensuring that the electric motor is shut off when any charging plug is connected during operation and that no battery power is supplied to it during the charge process.

#### 3.3.3 Compliant with ROPS & OPG top guard standards

The standard equipment includes a headguard meeting the ROPS (ISO 3471), OPG Top Guard Level I (ISO 10262), and Industrial Safety and Health Act standards. Used together with a retractable seatbelt, the operator is protected from being thrown from or falling out of the machine as well as from falling objects.



Fig. 9 ROPS & OPG (from the catalog)

### 3.3.4 Motor-in-operation beacon lamp

While the vehicle is in operation and the motor is running, the beacon lamp, which is installed behind the canopy, will light up and rotate to notify workers in the surrounding environment of its operation.



Motor-in-operation beacon lamp  
Beacon lamp for arm crane

Fig. 10 Beacon lamp (from the catalog)

### 3.3.5 Safety equipment equivalent to the PC30/35MR-5

The PC30E-5 is equipped with all of the well-received safety devices of the PC30MR-5 including:

- Lock lever automatic locking function
- Seat belt warning
- Secondary motor stop switch

Like the secondary engine stop switch in internal combustion excavators, the secondary motor stop switch is installed at the bottom of the operator's seat in case of an emergency.

## 3.4 Maintainability

### 3.4.1 Separation of high-voltage section

By concentrating the daily inspection sections in the front and the high voltage section centrally located at the rear of the machine and only accessible by qualified personnel, quicker operation and safer maintenance of the machine are made possible.



Fig. 11 Maintenance

### 3.4.2 Significant reduction in daily inspections and periodic maintenance

Since internal combustion check items no longer exist, daily inspection and periodic maintenance items have been significantly reduced.

Table 3 Daily inspection check list

[Daily inspection items] (9 → 5 items)

● : Required; - : Not required

Replacement parts	PC30E-5	PC30MR-5
Drain mixed water and sediment from fuel tank	-	●
Check the dust indicator	-	●
Check water separator and drain water and sediment	-	●
Check the oil level in hydraulic tank and replenish it	●	●
Check the coolant level, add coolant	●	●
Check the electric wiring	●	●
Check the fuel amount (remaining battery capacity)	●	●
Check the horn	●	●
Check the floor tilt fixing bolts	-	●

**Table 4** Periodic replacement parts list  
**[Oil/grease replacement parts]** (9 → 6 items)  
 ● : Required; - : Not required

Replacement parts	Recommended replacement interval (h)	PC30E-5	PC30MR-5
Grease	300	●	●
Engine oil filter	500	-	●
Engine oil	500	-	●
Fuel filter	500	-	●
Hydraulic tank breather	500	●	●
Final drive gear oil	1000	●	●
Hydraulic oil filter	1000	●	●
Hydraulic tank strainer	2000	●	●
Hydraulic oil	2000	●	●

Engine- or fuel-related check items

### 3.4.3 Adoption of easy maintenance battery

The PC30E-5 uses the easy maintenance battery installed in the Komatsu Battery Forklift FE series. This eliminates the troublesome water replenishment, required for conventional liquid-type lead batteries, and ensures safety.

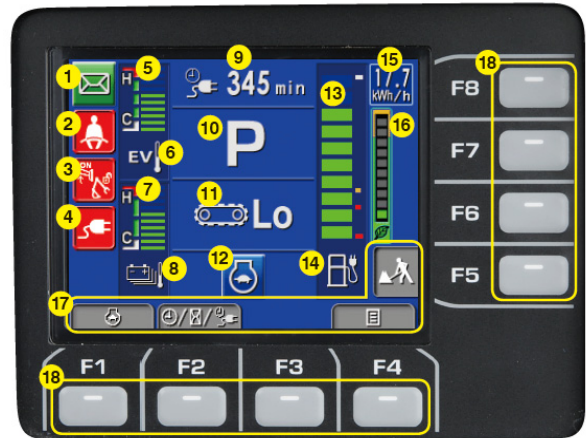


**Fig. 12** Battery assembly

## 3.5 ICT

### 3.5.1 3.5-inch high-definition LCD monitor

The PC30E-5 has a color LCD multi monitor, which displays various cautions and different sets of vehicle information on the screen in an easy-to-understand manner. It allows the operator to grasp the status of the machine at a glance, including battery-operation-related items such as the remaining battery capacity, charging cable connection status, and power consumption. Besides, various information can be obtained with button operation such as operating time, charged energy, electric charge, and accumulated CO<sub>2</sub> emission amount.

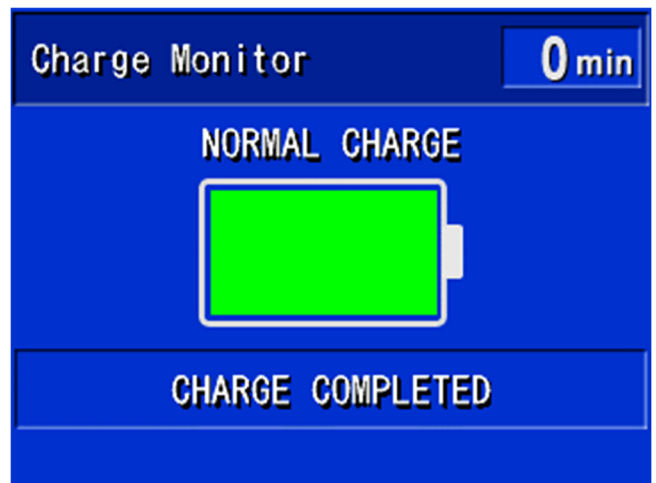


Indicators and operation switches

- |                                               |                                            |
|-----------------------------------------------|--------------------------------------------|
| 1 User message indication                     | 10 Work mode indication                    |
| 2 Seat belt non-tightening warning lamp       | 11 Travel speed indication                 |
| 3 Lock lever indicator lamp                   | 12 Auto-decelerator indicator lamp         |
| 4 Charging cable connection warning lamp      | 13 Remaining battery capacity gauge        |
| 5 Electric component temperature gauge        | 14 Remaining battery capacity caution lamp |
| 6 Electric component temperature caution lamp | 15 Average power consumption               |
| 7 Battery temperature gauge                   | 16 Instantaneous power consumption         |
| 8 Battery temperature warning lamp            | 17 Guidance icon                           |
| 9 Service meter / clock / workable time       | 18 Function switch                         |

**Fig. 13** Multi monitor (during operation)  
 (from the photograph in the catalog)

During charging, the charging progress is displayed on the LCD monitor in six steps while it is also displayed at the charging indicator lamp placed above the charging inlets.



**Fig. 14** Multi monitor (during charging)  
 (from the catalog)

### 3.5.2 Remote monitoring of the daily battery status by KOMTRAX

The PC30E-5 displays additional battery management information such as charging history and charged energy in addition to the conventional machine operating status and location information.

Such information allows not only grasping of electric energy used, CO<sub>2</sub> emission amount and running costs, but also forecasting and prolonging the battery life.

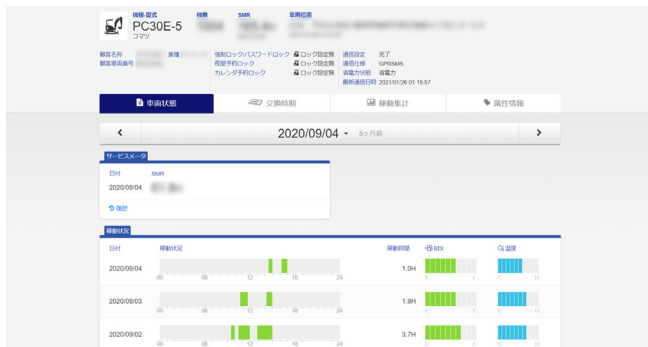


Fig. 15 Service Meter Reading (SMR) / operation information

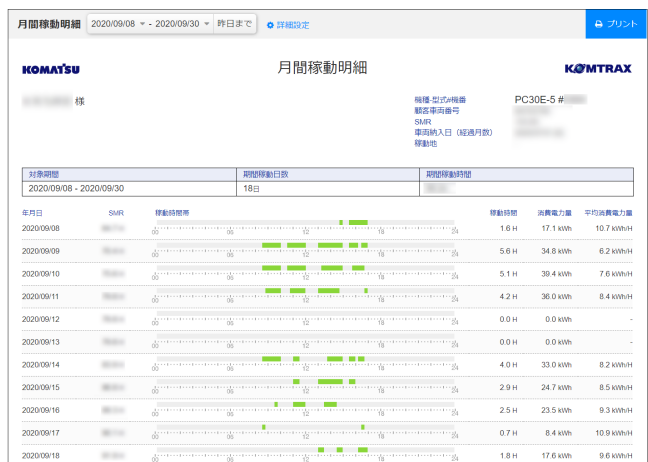


Fig. 16 Monthly Operation Details Report

## 4. Conclusion

This paper introduced the PC30E-5 which was exhibited at the Bauma 2019 held in Munich, Germany and was later introduced to the Japanese market in 2020. In this development, to establish our electrification technology, we incorporated not only technologies cultivated so far but also various new technologies such as on-board normal charger and battery management and conducted the same field test applied for internal combustion mini excavators.

We have received more positive feedback than we had imagined from machine users who approve of the machine's safety and environmental performance. We are proud to have established the new category of battery-powered/electric mini excavators.

### Introduction of the authors



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### [A comment from the authors]

Since there was no precedent or prior track record in the development of electric construction machinery, we performed repeated trials from the drafting phase through tests at customer sites. Thus, the development became a long journey. However, with the outpouring of favorable response we feel we have succeeded in creating a stepping stone for the electrification of the construction industry.

We hope to continue to evolve “the electrification of construction machinery that is friendly to the operator, people around it, and the environment” and to release attractive products that will further satisfy our customers.