

# “Pioneering” Product and Market Development of Large Electrically Driven Hydraulic Excavators Enjoying Strong Demand in Emerging Economies

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*OVERVIEW: Emerging economies are now the most important markets for manufacturers of construction machinery and they are the source of a growing share of total sales at Hitachi Construction Machinery Co., Ltd. Prompted by this trend, Hitachi decided to establish a new product series by updating its range of large electrically driven excavator models that comply with environmental regulations and are in strong demand from natural resource companies. Excavators have already been supplied to Thailand, China, Zambia, CIS countries, South Africa, and elsewhere where they have been well received. Although emerging markets have a strong potential for growth, they also present a number of risks. For a manufacturer of construction machinery to succeed in these emerging markets, it is important that business operations be conducted in a way that takes full account of these risks and it is also essential to have structures in place that can support this machinery which is used as production equipment.*

## INTRODUCTION

AGAINST the background of the sudden increase in oil prices, there has been growing demand

from resource companies in emerging economies for electrically driven excavators as well as for conventional models driven by a diesel engine.

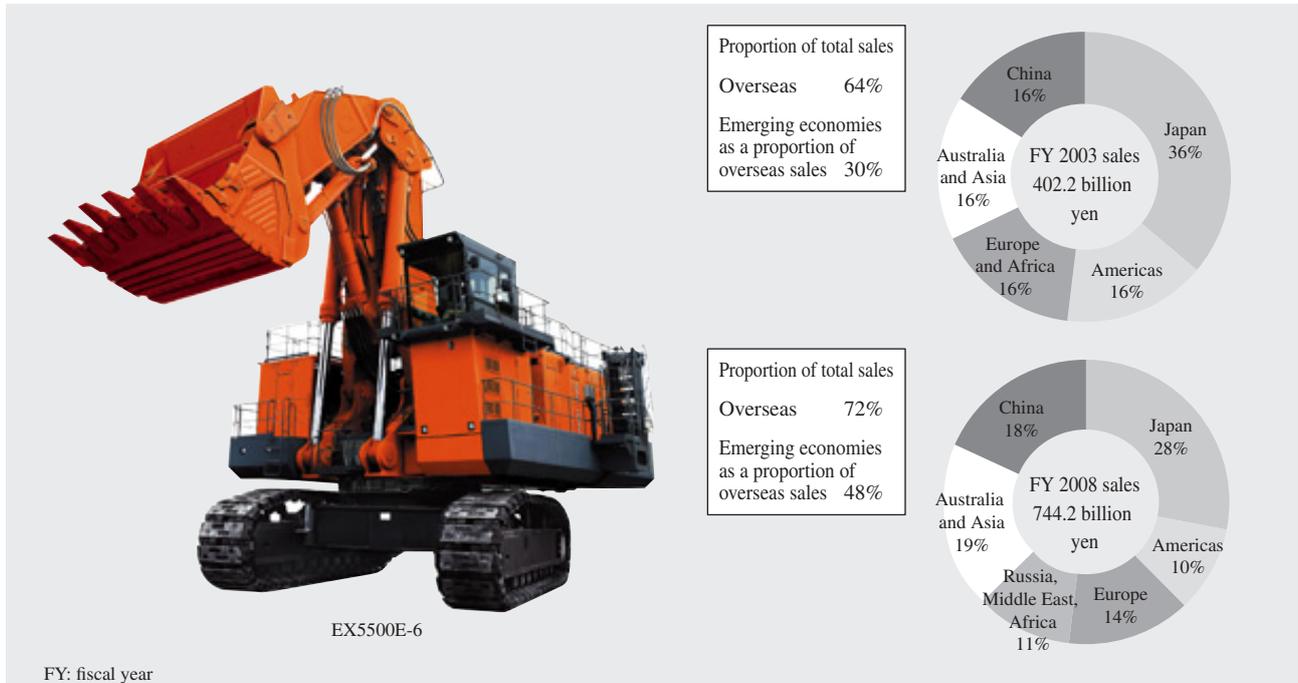


Fig. 1—EX5500E-6 Electrically Driven Hydraulic Excavator and Regional Breakdown of Excavator Sales by Hitachi Construction Machinery Co., Ltd.

Sales by Hitachi of construction and mining machinery to fast-growing emerging economies have expanded considerably.

Electrically driven models have the advantage of low maintenance costs and their environmental friendliness means they are a product Hitachi Construction Machinery Co., Ltd. hopes to sell more widely.

Although Hitachi designed its first large excavator with electrically driven hydraulics in the 1970s, the recent growth in market demand has seen this class of machine established as a product in its own right with a series of models available.

This article describes the background to the release of a new product series of large electrically driven hydraulic excavators, the risks associated with setting up business in emerging economies, and important considerations for the support of this machinery which is used as production equipment.

### IMPORTANCE OF EMERGING MARKETS

Construction and mining machinery are used in areas such as the construction of public infrastructure and the extraction of natural resources. The total value of sales to emerging economies has grown significantly in recent years, driven by factors such as the rising demand for resources and the economic growth that these countries have enjoyed. A comparison of the proportion of overseas sales by Hitachi in 2003 and 2008 shows how strongly sales to emerging economies have grown over this five-year period (see Fig. 1). The importance of emerging markets is expected to grow in the future and Hitachi intends to place an even greater emphasis on expanding its operations in these countries.

Hitachi is the largest manufacturer of very large hydraulic excavators for the mining industry with approximately 30% of the worldwide market. The number of excavators being sold is also growing as

the market for large hydraulic excavators expands against a backdrop of strong demand for resources (see Fig. 2). Having identified the market for mining machinery as being of the highest importance for the future, Hitachi is expanding its product range. One step in this direction is the consolidation into a product series of very large electrically driven hydraulic excavators for which demand from emerging economies continues to grow. Whereas diesel-powered excavators were the norm in the past, influences such as the high oil price have led to an ongoing strengthening in the demand for electric models and Hitachi is positioning itself to meet the requirements of customers in emerging economies.

### ADVANTAGES OF LARGE ELECTRICALLY DRIVEN EXCAVATORS AND BACKGROUND TO THEIR DEVELOPMENT

The history of Hitachi's development of electrically driven hydraulic excavators goes back to the late 1970s and an enquiry from a quarry operator in South Africa. The economic sanctions to which the country was subject at the time made it impossible to obtain sufficient diesel fuel and this led to the request for an excavator that could use cheap electricity as an alternative source of energy. The 150-t excavator that Hitachi developed and supplied in response to this request was the first ever large excavator to be electrically powered. Although it was hoped that further sales could be made in other regions, little success was had and despite having the top share in the international market for very large diesel-powered excavators, Hitachi fell well behind European manufacturers in the electric excavator sector.

The turnaround came in 2001 with a surface excavation project by the electricity authority in the Kingdom of Thailand. Because the project was able to obtain cheap electricity from a power plant located next to a coal mine, the customer's requirement was for electrically driven excavators. After intense competition, Hitachi finally won an order for 10 250-t class very large electrically driven hydraulic excavators and 40 dump trucks with a 100-t capacity.

Since this time, demand for electrically driven hydraulic excavators has grown against a background of sharp rises in the oil price and the need for replacement machinery that came with growing demand for resources. With numerous enquiries coming from Africa, Eastern Europe, the CIS (Commonwealth of Independent States) countries,

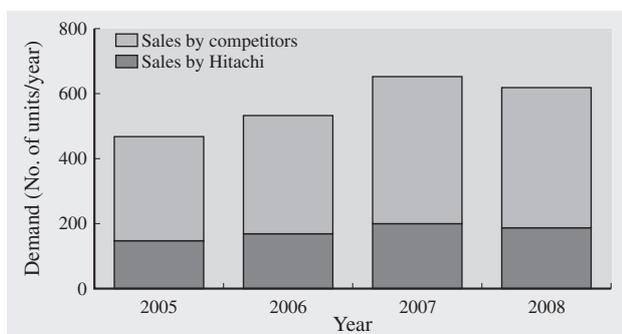


Fig. 2—Worldwide Demand for Very Large Hydraulic Excavators (100 t or larger) in Terms of Number of Units. Hitachi has secured approximately 30% or more of the worldwide market for very large hydraulic excavators.

and the People's Republic of China, the decision was made to develop a product series consisting of five models of electrically driven hydraulic excavators (190 to 800 t) to satisfy the requirements of these emerging economies.

Electrically driven hydraulic excavators have the following advantages over excavators that use a diesel engine.

- (1) Fuel consumption is approximately one-fifth of diesel engine excavators.
- (2) Maintenance cost savings of 20 to 30%
- (3) No exhaust emissions
- (4) No leaks of fuel or engine oil
- (5) Lower noise

On the other hand, the problems faced by electrically driven hydraulic excavators include the requirement for an electricity supply cable which makes travel over long distances difficult and means they cannot be used in locations where no power supply is available. Despite this, they are a very valuable class of equipment at mines where the necessary electricity supply infrastructure is in place. Also, they represent a good match with what companies are looking for in the current circumstances, notably cost savings and environmental friendliness, and Hitachi is working actively to establish the product around the world.

The following sections describe the situation in each country and region in turn.

## **ACTUAL USE AND DELIVERIES TO EMERGING ECONOMIES AND REGIONS**

### **Asia**

Table 1 lists actual deliveries of electrically driven hydraulic excavators to emerging economies. The 10 units of 250-t electric excavator supplied to Thailand are still in operation and have earned an excellent reputation. An order for 10 additional units is expected from the Thai electricity authority in 2010.

Although China has used a mix of imported machinery and domestically produced rope-operated excavators in the past, active approaches from Hitachi over a number of years have gained orders for two 250-t class models and two 350-t class models from a large coal miner and an electricity company. Given China's low per capita electricity consumption and its prospects for ongoing growth, there appears to be great scope for supplying Hitachi's highly reliable electrically driven hydraulic excavators for use in the routine production of coal and iron ore.

TABLE 1. Deliveries of Electrically Driven Hydraulic Excavators  
*The table lists the model, weight class, number of units, country, and date for each sale.*

Model	Weight class (t)	No. of units	Country	Date
UE30E	70	3	South Africa	1970s
UH501E	90	2	India	1980s
UH801E	160	1	South Africa	1980s
UH801E	160	2	China	1980s
EX2500E	242	10	Thailand	2002
EX2500E	242	1	India	2002
EX2500E	242	2	Bulgaria	2007
EX2500E	242	4	Thailand	2007
EX5500E	518	4	Zambia	2008
EX2500E	242	2	China	2008
EX5500E	518	1	Kazakhstan	2008
EX3600E	350	1	South Africa	2008
EX3600E	350	2	China	2009

### **Africa**

An order was received for four very large 550-t class electrically driven hydraulic excavators for a new copper mine project in the Republic of Zambia. The order included 26 trolley dump trucks with a capacity of 280 t and was amongst the largest that Hitachi's mining machinery business has ever received. A feature of these trolley dump trucks is that they are driven by AC (alternating current) electric motors obtaining electric power directly from cables when traveling uphill. This provides significant fuel savings because it allows the engine torque and speed to be reduced.

This large copper mine project now employs more than 3,000 people and is seen as contributing strongly to Zambia's economic growth. Hitachi Construction Machinery subsidiary in Southern Africa also has about 100 staff based at the site where they provide a comprehensive machinery maintenance service that operates seven days a week, 24 hours a day.

A coal mining project of similar size is also underway in neighboring Republic of Mozambique. The project has placed orders for very large 550-t class hydraulic excavators (diesel powered) which are scheduled for delivery in early 2010. Although European manufacturers have traditionally been strong in the African market, Hitachi aims to use these large projects as a foothold from which it can expand its African business.

### **Russia, CIS Countries, and Eastern Europe**

Although Hitachi has had commercial operations in Russia for a long time, it has also recently received orders for nine 350-t class excavators from three

different iron ore mining companies in Ukraine and the Republic of Kazakhstan. Although the commodity boom was a background factor, the Hitachi excavators were chosen despite their higher cost because of their excellent cost-performance in terms of utilization and maintenance costs compared to the existing Russian-built rope-operated excavators that these companies had been using. Although the current financial crisis is likely to pose quite a few obstacles between now and delivery, the high productivity of Hitachi’s hydraulic excavators has been recognized as the basis of their superiority and this is a market that can be expected to grow over the long term.

**TECHNOLOGY BEHIND ELECTRICALLY DRIVEN HYDRAULIC EXCAVATORS**

Electrically driven hydraulic excavators use a three-phase induction motor in place of the diesel engine traditionally used as the power source. Fig. 3 shows an EX5500E-6 electrically driven hydraulic excavator in operation.

The electric motor is used to drive the hydraulic pump. The fluid output of the pump is in turn supplied to the hydraulic motors or cylinders that operate the machinery. The power used to drive the electric motor is supplied via an external electric cable.

Fig. 4 shows an electric motor and hydraulic pump assembly. The six main hydraulic pumps, each with a maximum hydraulic power of 130 kW, and an auxiliary hydraulic pump are connected to the pump transmission which is driven by a three-phase induction motor with an output of 860 kW. The electric motor and pump transmission are



Fig. 3—Electrically Driven Hydraulic Excavator in Operation with Very Large Dump Truck. The very large EX5500E-6 electrically driven hydraulic excavator and EH4500 dump truck are in use at the Lumwana copper mine in Zambia.

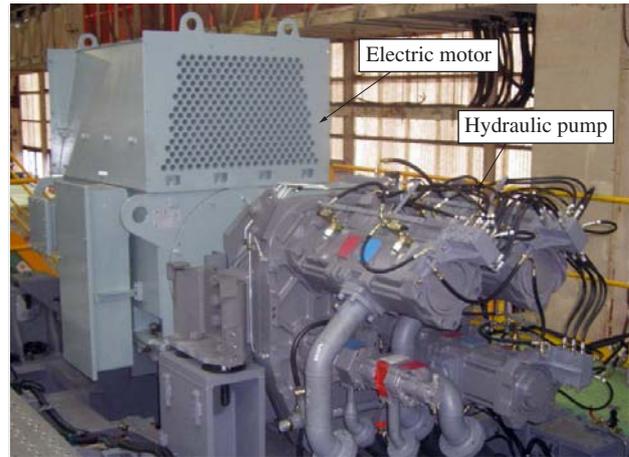


Fig. 4—Electric Motor (860 kW) and Hydraulic Pump Assembly in EX5500E-6 Excavator.

The electric motor and hydraulic pump assembly are shown.

both attached to the base bracket and the motor output shaft connects to the input shaft of the pump transmission by a flexible coupling. The base bracket is supported on vibration-resistant rubber to protect the electric motor from mechanical shock during excavator operation.

Table 2 lists the output powers of the Hitachi TFOA-KK electric motors (6.6 kV) used in the excavators.

Fig. 5 shows the layout of the high-voltage equipment in an EX5500E-6 electrically driven hydraulic excavator.

The electricity for the motor is supplied from a substation at the work site via a cabtire cable supplied by Hitachi Cable, Ltd. (made up of three power lines, and earth line, and two signal lines). The cable connects from the base runner to the Hitachi cubicle fitted on the upper wheel via a slip ring (also made by Hitachi Cable) that is attached at the center of rotation. The cubicle controls starting and stopping of the electric motor. The reactor method is used for motor starting to halve approximately the startup current. A protection function shuts down the motor in the event of a problem if motor overheating, phase

TABLE 2. Motor Output for Each Model  
The table lists the output powers of the Hitachi TFOA-KK electric motors used in each excavator model.

Model	Machine weight (t)	Electric motor output (kW)
EX1900E-6	186	610
EX2500E-6	242	860
EX3600E-6	350	1,200
EX5500E-6	518	2 × 860
EX8000E-6	780	2 × 1,200

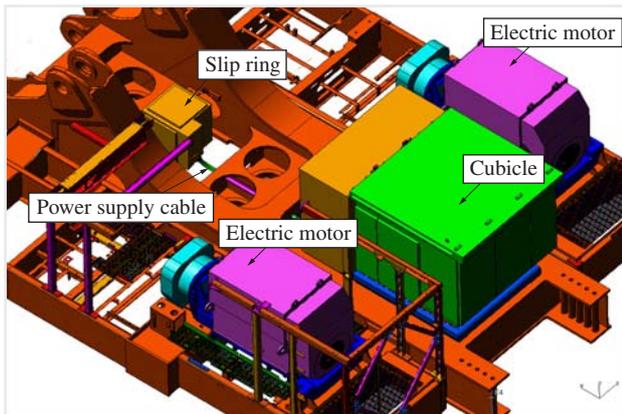


Fig. 5—Layout of High-voltage Equipment in EX5500E-6 Excavator.

The layout of the high-voltage equipment in an EX5500E-6 electrically driven hydraulic excavator is shown.



Fig. 6—Layout of EX5500E-6 Cab.

The operator is kept updated on the state of the machine by meters, warnings, and other indicators that appear on the monitor display.

loss, phase reversal, or over-current are detected. Also, warnings and motor coil temperature, current and voltage values are converted to signal voltages and sent to a standalone monitoring and control unit. Meanwhile, the operator is kept updated on the state of the machine by meters, warnings, and other indicators based on the signals input from the cubicle that appear on the monitor display mounted in the cab as shown in Fig. 6. As there is no speed control for the electric motor, it runs at constant speed while the excavator is in use.

## ISSUES WHEN ENTERING EMERGING MARKETS

Emerging economies are likely to be the future driving force for the world economy and demand for natural resources is expected to return to its recent high levels. Because the breakdown of an excavator at a mine can affect the entire operation, the primary

consideration for customers is that the equipment will not fail despite being used in a harsh environment. In other words, reliability is critical and this is also the source of the high reputation enjoyed by Hitachi machinery. While supplying machinery with a high level of performance is essential, being able to demonstrate reliability is also a very important aspect of establishing markets in emerging economies and this directly impacts on a manufacturer's reputation.

The next important factor is the ability to provide after-market support. Mining machinery is often operated in inconvenient locations away from major cities. In emerging economies in particular, logistics is often erratic and it is not uncommon for support equipment and skills to be inadequate. Having appropriate maintenance parts on site, ensuring that repair tools are available, and improving staff capabilities are the most important requirements for keeping machinery going in a harsh environment. Amongst recent orders, those that bundle maintenance services along with the machinery itself continue to increase in number, making the obtaining of high quality staff a serious issue. To this end, Hitachi has established training centers to improve the skills of technical staff in China, the Republic of Indonesia, and emerging economies in Africa and elsewhere to improve further the capabilities of local staff.

Various different types of risk are associated with expanding operations in emerging economies. The fragile economic foundations of emerging economies make them vulnerable to changes in economic conditions and they also pose debt repayment and political risks. In Africa and Central and South America in particular, there is a constant need for vigilance against disease and threats to the public order. This makes it necessary to take full account of these risks when planning to venture into these markets, and important to find out as much as possible beforehand and from various different sources.

## CONCLUSIONS

This article has described the background to the release of a new product series of large electrically driven hydraulic excavators, the risks associated with setting up business in emerging economies, and important considerations for the support of this machinery which is used as production equipment.

Hitachi intends to continue to expand its business in emerging markets on the basis of thorough risk management from many different angles.

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