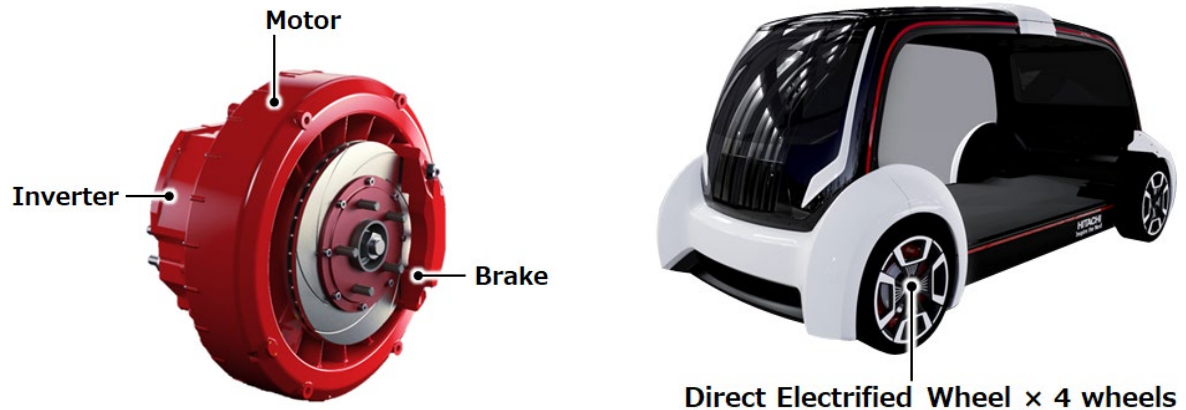


News Release

FOR IMMEDIATE RELEASE

**Compact, Lightweight Direct-Drive System
to Make In-Wheel Electric Vehicles Closer to a Production Reality**
World-class 2.5 kW/kg power density motor integrated with inverter and brake
in a single unit, installed inside wheel



Tokyo, September 30, 2021 --- Hitachi, Ltd. (TSE: 6501, “Hitachi”) and Hitachi Astemo, Ltd. (“Hitachi Astemo”) today jointly announced the development a compact, lightweight direct-drive⁽¹⁾ system for the increasingly popular EV segment,⁽²⁾ which combines the motor, inverter, and brake into a single unit (Fig. 1). This enables the installation of the entire system into the wheel, thus moving the world one step closer to a zero-emissions society. The new motor transmits the high drive force necessary to run an EV directly to the wheels, and its lightweight design and world-class 2.5 kW/kg power density⁽³⁾ significantly limit the weight increase traditionally associated with in-wheel units. Moreover, adopting an in-wheel unit does not require a substantial change to the existing configuration of the suspension and other components. Driveshafts and other indirect mechanisms have been eliminated, allowing motor power to be applied directly to EV operation. This reduces energy loss by 30 percent and increases the range on a single charge compared to existing EVs.

Hitachi and Hitachi Astemo will continue research into practical implementation of the technology, which enables more expansive interior and battery installation spaces. In addition to the vehicle control technology it has been developing, Hitachi Astemo will apply the new direct-drive system to its already-extensive, global EV product lineup.

Background and additional information

There is growing investment activity and technological development towards realizing a decarbonized society. In the motor vehicle sector, there is an especially strong legislative push for transitioning from gasoline-driven vehicles to EVs. In conventional EVs, the drive system is placed on the chassis, which limits interior and/or battery space. Fitting the motor inside a wheel has been identified as a solution, but this increases the weight in the wheel and requires sweeping changes to the existing brake and suspension components.

To address this, Hitachi and Hitachi Astemo's lightweight direct-drive system—drawing on Hitachi Group's broad technology and product development in the mobility space that includes railways and elevators—combines motor, inverter, and brake into a single in-wheel unit for EVs. The features of the technology are as follows:

1. Halbach array magnets and innovative flat coils produce world-class power density

Increasing the number of magnetic poles is effective in improving a motor's drive force, but has shortcomings—namely, that it reduces the proportion of magnetic flux that can be effectively used, and necessitates more coil weld points and welding space. By placing the magnets in a Halbach array,⁽⁴⁾ Hitachi and Hitachi Astemo have succeeded in improving drive force by increasing the effective magnetic flux of each magnetic pole, and made the motor lighter by using beam welding⁽⁵⁾ to create a high-density array of flat coils, thus achieving world-class 2.5 kW/kg power density. This limits the in-wheel weight increase of the EV, and avoids the increased energy consumption that's characteristic of conventional, heavier in-wheel systems.

2. Direct-drive system incorporating a single motor, inverter, and brake unit

Prior EV motors have low power density and monopolize space inside the wheel to provide sufficient drive force, which make it difficult to use existing brakes and suspension components. Space is also needed for a dedicated and electrically insulated coolant channel, which prevents electrical faults from occurring when power semiconductors in the inverter come in contact with coolant. The newly developed system uses direct-cooling technology, in which high-insulating cooling oil directly cools the power semiconductors and is cycled to the motor to directly cool the coils. This combined with the single-unit drive system—which integrates a motor, brake and inverter—significantly reduces the space taken up by cooling pipes, and enables in-wheel installation without having to significantly alter the existing configuration of suspension and other components.

The technology will be exhibited in part at the 30th Aachen Colloquium, from October 4 to 6 in Aachen, Germany.

- (1) Direct-drive: A drive system in which the drive force of a motor is directly transmitted to the wheels.
- (2) EV: electric vehicle.
- (3) Motor power density: Ratio of motor output to weight. Weight includes the motor housing and the driveshafts.
- (4) Halbach array: A magnetic array in which the orientation of the N pole of each magnet is rotated 90 degrees to create high-density magnetic flux at each of the magnetic poles of a motor.
- (5) Beam welding: A welding method in which the beam is concentrated on specific areas of metal to spot-weld.

■ Specifications of direct-drive system

Item	Value
Motor power density	2.5 kW/kg
Wheel size	19 in.
Maximum output	60 kW
Maximum torque	960 Nm
Supplied voltage	420 V
Maximum electric current	280 A

■ Direct-drive system video

<https://www.youtube.com/watch?v=mnuQl83idEc>

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About Hitachi, Ltd.

Hitachi, Ltd. (TSE: 6501), headquartered in Tokyo, Japan, is contributed to a sustainable society with a higher quality of life by driving innovation through data and technology as the Social Innovation Business. Hitachi is focused on strengthening its contribution to the Environment, the Resilience of business and social infrastructure as well as comprehensive programs to enhance Security & Safety. Hitachi resolves the issues faced by customers and society across six domains: IT, Energy, Mobility, Industry, Smart Life and Automotive Systems through its proprietary Lumada solutions. The company's consolidated revenues for fiscal year 2020 (ended March 31, 2021) totaled 8,729.1 billion yen (\$78.6 billion), with 871 consolidated subsidiaries and approximately 350,000 employees worldwide.

Hitachi is a Principal Partner of COP26, playing a leading role in the efforts to achieve a Net Zero society and become a climate change innovator. Hitachi strives to achieve carbon neutrality at all its business sites by fiscal year 2030 and across the company's entire value chain by fiscal year 2050.

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For more information on Hitachi, please visit the company's website at <https://www.hitachi.com>.

About Hitachi Astemo, Ltd.

Headquartered in Tokyo, Japan, Hitachi Astemo is a joint venture between Hitachi, Ltd. and Honda Motor Co., Ltd. Hitachi Astemo is a technology company that develops, manufactures, sells and services automotive and transportation components, as well as industrial machinery and systems. For more information, visit the company's website at <https://www.hitachiastemo.com/en/>.

For more information, use the enquiry form below to contact the Research & Development Group, Hitachi, Ltd. Please make sure to include the title of the article. <https://www8.hitachi.co.jp/inquiry/hqrd/news/en/form.jsp>

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