

(1) Purpose

Compared with other means of transportation, railways offer a number of excellent characteristics such as high-energy efficiency and reduced impact on the global environment. Therefore, clarifying the excellent characteristics of the Tokaido Shinkansen and other railways will contribute to global environmental conservation. With such conservation in mind, we are aggressively working on ways to reduce energy consumption by Shinkansen train carriages.

(2) Social and technological requirements for technical issues

About 40 million people travel between the Tokyo and Osaka areas each year. A close examination of this economic and social artery shows that the transportation volume provided by the Tokaido Shinkansen during fiscal 2006 was approximately equal to that provided in fiscal 1990, but that CO₂ emissions declined substantially due to energy conservation efforts. **[1]** In contrast, while the transportation volume provided by aircraft grew due to an increase in the number of flights, the volume of CO₂ emissions from aircraft almost doubled. In fact, the transportation data for fiscal year 2006 indicates that a transportation shift from aircraft to the Tokaido Shinkansen could reduce the total amount of CO₂ emitted from 900,000 tons to 390,000 tons annually,

This indicates that even though the time required for an aircraft and a Tokaido Shinkansen to travel between the two cities is roughly the same, depending on the transportation selected, **[2]** CO₂ emissions could be curtailed by as much as 510,000 tons yearly. This equals the annual CO₂ emissions from about 98,000 general households.

If this shift had been assumed from fiscal 1990, the reference year of the Kyoto Protocol, total emissions could have been curtailed about 30%, from approximately 580,000 tons to approximately 390,000 tons.

(3) Potential mechanisms for achieving key parameters

JR Tokai has worked diligently to improve energy conservation by upgrading the train carriages and making other qualitative and quantitative improvements. An example of these efforts is reflected in the upgrades to Tokaido Shinkansen carriages. While the maximum speed of the Tokaido Shinkansen was 220 km/h at its 1987 inauguration, due to carriage speed improvements, it was raised 50 km/h to a top speed of 270 km/h in 1992 with the introduction of the Series 300 model trains. This increase was the result of aggressive efforts to improve power electronics and other technologies. Since that time, at relatively short cycles of seven to eight years, the train carriages have been further upgraded to Series 700 and Series N700.

Furthermore, simulations conducted on the Tokyo and Shin-Osaka run showed a remarkable decrease in energy consumption by the Series N700, which is just half of that consumed by Series 0 trains, despite the fact that the maximum speed of Series 0 trains was 32% slower. These improvements are the results of stringent carriage weight reduction, aerodynamic streamlining, power regenerative braking that recycles consumed energy, the carriage-body tilting system, and other new technologies.

■ Reduction of carriage weight

Carriage weight reduction greatly improves energy conservation performance. After the Series 300, we adapted bolsterless trucks to Series 700 and N700 models because of their simpler structures. The Series 700 and N700 also adopted bodies made of lightweight aluminum alloy instead of the steel bodies used in the Series 0 and 100 trains. Furthermore, the Series 0 and 100 trains used DC motors, while the Series 300 and later trains adopted extremely efficient and compact AC motors that epitomized the advances in semiconductor technologies. These and other efforts have made Series 300 or later carriages over 250 tons each lighter Series 0 carriages.

■ Reduction of running resistance

To reduce running resistance, a new nose shape that provides excellent aerodynamic characteristics was developed for Series N700. The nose shape was the result of approximately 5000 computer simulations and wind tunnel experiments. The shape was named "Aero double wing" because it resembles a bird flying with outstretched wings. For cabin windows, the window glass was integrated with the metal exterior of the carriage to create a smooth surface with no level differences. Furthermore, the joints between each carriage are covered with hoods designed to provide a smooth exterior to the entire train. These efforts have reduced the running resistance of Series N700 trains by about 20% in comparison compared with the Series 700.

■ Extension of power regenerative brake

A power regenerative brake system converts kinetic energy into electric energy (power generation) by using electric motors as generators during braking, and then channeling the generated power to the overhead line for use by other trains, has been adopted. JR Tokai put power regenerative braking to practical Shinkansen use, for the first time, with the Series 300 and has continued to use it with Series 700 and N700 trains.

For Series 700 trains, 12 of the normal 16 carriages were equipped with the brake system, but with the Series N700, the brake systems was extended to 14 carriages in order to acquire all the braking force usually required for a train equipped with the power regenerative brake system. This has further raised the energy efficiency and contributed to reductions in Shinkansen energy consumption.

■ Implementation of carriage-body tilting system

To increase operating speeds on speed-limited curves, the Series N700 adopted a carriage-body tilting system. This system enables the train to negotiate curves at increased speed while maintaining a comfortable ride. The system has resulted in time savings not just for negotiating the curves, but by reducing the need for acceleration and deceleration as well as its frequency. This has made further contributions to energy conservation.

When the Shinagawa Tokaido Shinkansen station was opened in October 2003, we replaced all carriages with the high-speed, energy-efficient Series 700 and 300 models.

In July 2007, The Series N700, which offers improved service and environmental performance entered service. Use of this model had reduced energy consumption (*) by about 19% at the end of fiscal 2007. (*Based on the amount of energy require to operate run one carriage for 1 km).

By fiscal 2011, 80 trains consisting solely of Series N700 carriages will be in operation and thus strengthen the environmental superiority of the Tokaido Shinkansen. By improving our service and encouraging more users to select and use Tokaido Shinkansen, we will contribute to reducing the environmental load of the entire transportation sector.

(4) Future society outlook

Various means of transportation have different characteristics. For long-distance transport to overseas destinations, aircraft may be the most suitable means available. However, for rather short distances and areas of great demand, such as the route between the Tokyo and Osaka areas, it is clear that the Shinkansen is a rapid and suitable mass transportation system.

By shifting passenger demand to the environmentally superior Shinkansen, CO₂ emissions can be curtailed. As one of the solutions to the global warming problem in the 21st Century, we think that role sharing by utilizing the optimum characteristics of each means of transportation is necessary to reduce the environmental burden caused by the entire sector.

			Baseline	Climate plan		
			2007	2015	2030	2050
[Name of the technology/solution]	Savings	Consumption if old technologies are sustained (BAU)	100	90	85	80
		Consumption after implementing new technology and measures		80	60	40
		Net saving		10	25	40
	Cost (Investment, operation & maintenance, fuel)			100	110	120
	Cost Per PJ saved			-	-	-
	GHG reduction potential	Emission if old technologies are sustained and with current trends (BAU)	100	90	85	80
		Emission after implementing new technology and measures		80	60	40
		Total Reduction		10	25	40
		Cost of GHG reduction		100	110	120