# Why Did Japan Choose the 3'6" Narrow Gauge?

**Akira Saito**

'The reason why narrow gauge (1067 mm) was adopted for early Japanese railways is unclear.' This is the first sentence of Chapter 6 in *A History of Japanese Railways, 1872–1999* written by four well-known specialists in Japanese railways and published in English by EJRCF. (Some Japanese readers might hope for a Japanese version too.)

I was invited to the publishing party on the book's completion and while glancing through my copy I came across the above sentence. Surely, I thought, more can be said on the subject than just that. There may never have been a written record explaining why the 3'6" narrow gauge was adopted for the first Japanese railways, but even if there was, no historian has ever found it. My guess is that the final decision was probably made Vice Minister of Finance Shigenobu Okuma (1836–1922) in the Meiji government assisted by his interpreter, Masaru Inoue (1843–1910), the only Japanese expert in rail technology at the time. Perhaps the two men discussed the decision later, but whatever was said has been lost with the passage of time. This is not a trivial matter, because their decision cannot be disregarded on Japanese railways.

Since the likely two prime movers in the decision left no 'confession,' we must journey into the past and discover the reason for ourselves. After my mind started working on this track, I decided to take up the quest for an answer—my search was to lead me to Wales and the Isle of Man in the UK, and to Norway.

Early steam engines were huge. They had to be, because their power came from atmosphere pressures, and the only way to boost output was to increase piston area. Even after locomotives began using high-pressure steam, a similar rule applied—the larger the locomotive, the more power it had. Also, steel was an expensive commodity so all early locomotives were made of weaker wrought or cast iron. For the same reason, locomotives were made stronger by making them bigger, explaining why the 7' broad gauge once offered advantages over Robert Stephenson & Company's 4'8" standard gauge. Until the mid-1850s, a railway builder could only choose between standard gauge and broad gauge, explaining why standard gauge was called narrow gauge in those days!

Gradually, standard gauge spread throughout Britain and into other parts of Europe but when the builders began to look towards exports to less-developed areas, they preferred cheaper (and more profitable) construction methods. Legislation in England prohibited construction of narrow-gauge main lines, but the expansion of slate mining in Wales led to a search for some way to mechanize the human- and animal-powered mine railways that were mostly narrow gauge. Steam locomotives provided the answer and as the technology improved, it was realized that they could haul carriages on narrow-gauge lines too.

Here I must introduce Carl Abraham Pihl (1825–97), who was as important to Norway's railway development as Inoue was to Japan's. Pihl studied engineering at Chalmers Institute (now Chalmers University of Technology) at Gothenberg in Sweden and then went to England and apprenticed himself to Robert Stephenson (1803–59). Two years later, he began working on a railway construction project in eastern England. In 1850, he returned to Norway to join his country's first railway construction project, which had just started under the direction of Robert Stephenson himself. Pihl was the only Norwegian with any experience in rail engineering, and played an important role in building his country's first railway, a standard-gauge line that opened in 1854. He went back to England again to assist in construction of port and railway facilities, primarily in Wales and then returned home once more because of the Crimean War, becoming the first managing engineer of Norway's Railway Construction Bureau.

Norway only became fully independent from Sweden at the beginning of the 20th century and was nominally under Sweden's control when Stephenson and Pihl brought the first rail technology to the country. Clearly, the cheaper narrow gauge would have offered advantages to the builders partly because of Norway's difficult topography with many mountains, lakes and fjords and partly because of its backward economy. (At the time, Norway was the poorest region in Europe with a population of 2 million.) However, the first priority of the builders was to construct a link with Sweden which used the standard gauge, so Norway became standard gauge too. And even today, a Swedish company owns the locomotives and passenger carriages operating on the line running south-west from Oslo into Sweden, and the abridged timetable published in Norway does not even show the service.

Two or three years after the opening of the first standard-gauge line, it became apparent that although standard gauge was fine for a main international line, it would be very uneconomical to lay standard-gauge track in the mountainous areas. When the decision was made to construct other separate lines, Pihl successfully argued that the next two should be narrow gauge to keep construction costs down. He had a possible choice of two narrow gauges: the 3'6" narrow gauge or the meter narrow gauge. Since both Stephensons (George and Robert) were locomotive manufacturers, they could adapt their engines to any track gauge, but they were still not completely sure about performance on narrow gauges and had tried a number of experiments in a mine that they operated. Robert Stephenson died in 1859 giving his protégé Pihl several years to get some opinions from the master on narrow track gauges. Pihl seems to have decided that the gauge of 3'3" or so were too narrow and settled on the 3'6" gauge, the first time the gauge had been used for a passenger line. His decision might also have been influenced by a preference for using inner valve gears, because the slightly wider 3'6" gauge offered more potential than the narrower gauge for using this design.

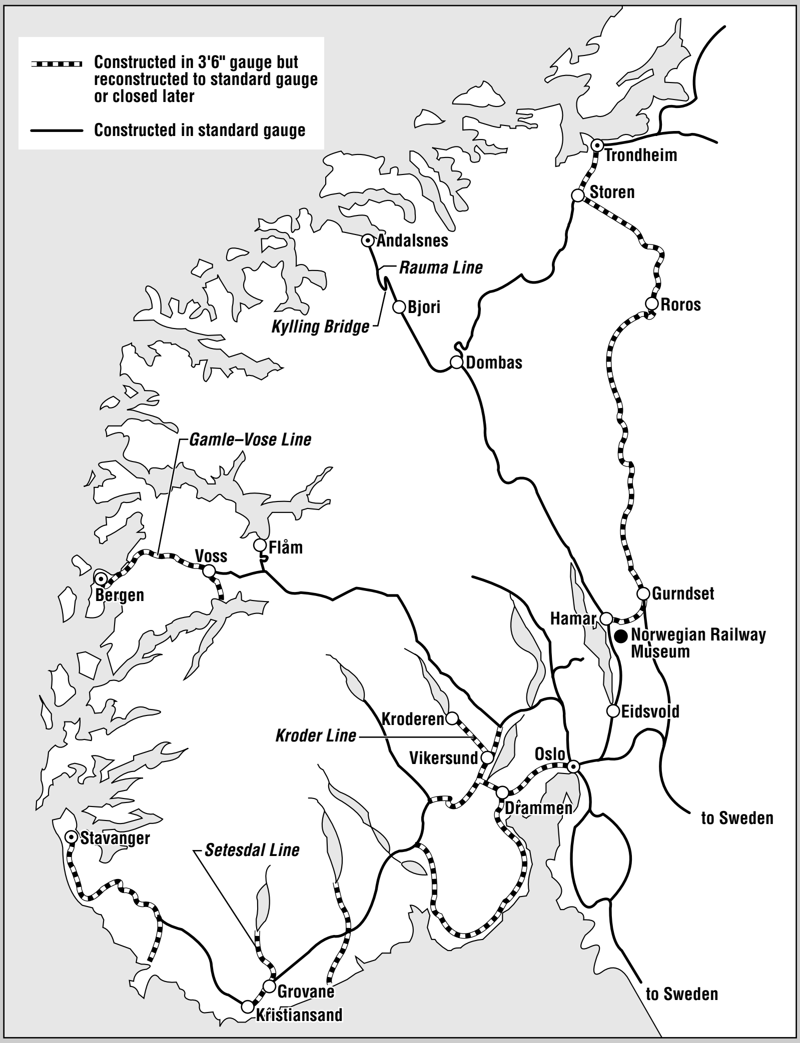
With the benefit of hindsight, Pihl was right to choose the 3'6" narrow gauge because it offers greater operating safety, higher transport capacity and better ride comfort than the 3', meter and other narrow gauges. But was Pihl the inventor of the 3'6" gauge? Perhaps the honour belongs more to Robert Stephenson because he manufactured the locomotives using this gauge and ran some trials, but even so, Pihl was a major force in getting the gauge accepted.

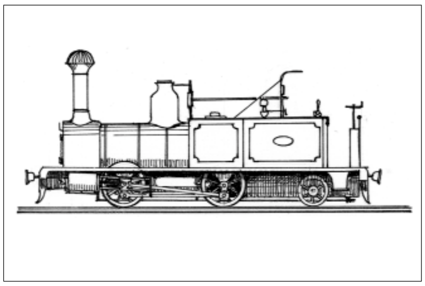
Norway placed its first order for a 3'6" gauge locomotive in 1860 and the first 3'6" narrow-gauge line opened in June 1862 from Hamar (120 km north of Oslo) to Grundset. A second 3'6" narrow-gauge track began linking the northern city of Trondheim on the Atlantic Ocean with the interior in August 1864.

The locomotives supplied by Robert Stephenson & Company had B-1 axles on a long (384 cm) fixed wheelbase with the trailing wheels mounted on a fixed frame. The fixed wheelbase was too long for the sharp curves in the Trondheim region and resulted in a derailment. The minimum radius for track curves around Hamar was 300 m, but in the northern Trondheim district, it was set at only 200 m or so, although Stephenson's company had insisted on a minimum radius of 300 yards (275 m).

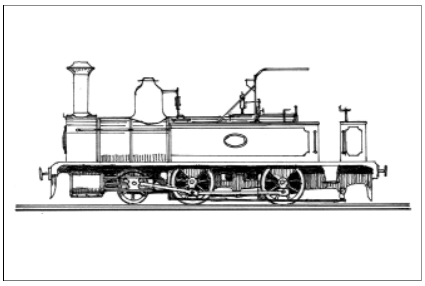
The railway then imported 1-B locomotives with swiveling, single-axle leading wheels and there were no more problems with derailment. Incidentally, Japan imported the same type of 1-B locomotive for its first Class 150, but the leading wheels were fixed. The locomotives also ran without problems because track curves were more gradual in Japan. Norway still has one 3'6" line

**Railway Network in Southern Norway**

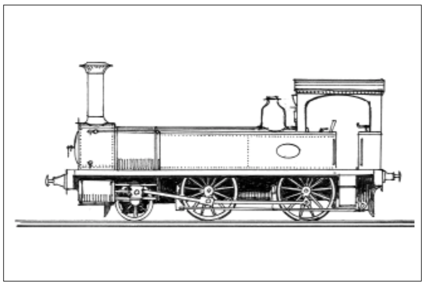


Locomotive by Robert Stephenson & Co. (1861) with B-1 axles on a long (384 cm) fixed wheelbase (Author)

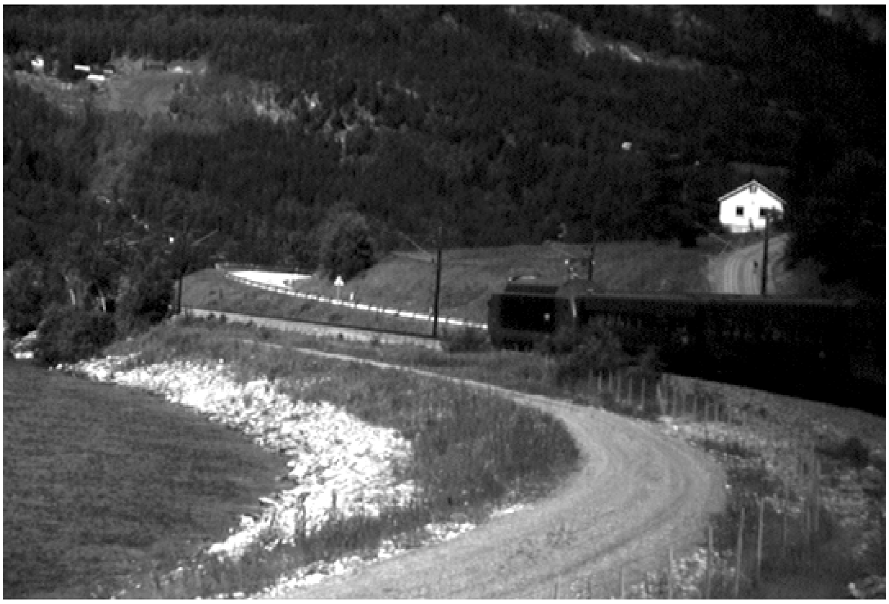


Avonside (1864) 1-B locomotive with swiverlling, single-axle leading wheels (Author)



Vulcan Foundry (1871) Class 150 1-B locomotive imported to Japan (Author)

Dübs 1-C-1 tank locomotive on Setesdal Line (Author)



You get an excellent view of the locomotive from the sixth carriage because the minimum curve radius seems to follow the 300-yard guideline recommended by Stephenson! (Author)

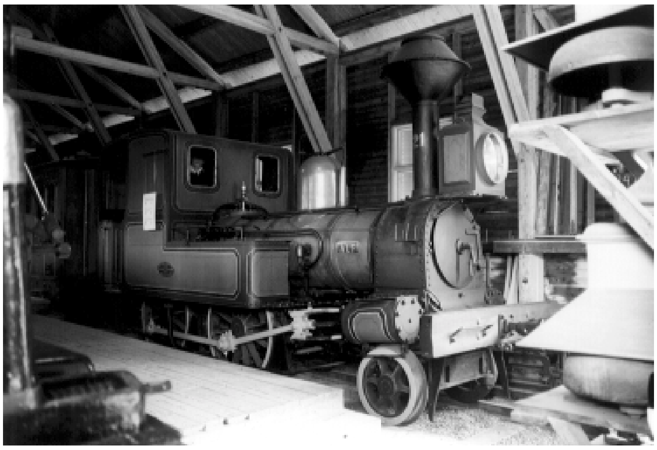
in operation—part of the former Setesdal Line near Kristiansand in southern Norway preserved as a vintage railway. It remains fairly untouched by time—a railway constructed to narrow-gauge specifications in order to save money. The 20- to 25-kg rails can accommodate an axle load of 6 tonnes and are so thin that the gauge appears wider than it is. A Dübs 1-C-1 tank locomotive with 914-mm driving wheels hauls three wooden passenger carriages up grades of 20 per mill. When the line was constructed, it was assumed that the locomotives would require a cable assist on any gradient greater than 25 per mill.

Here I'd like to digress for a moment. Norway's modern standard-gauge railways have plenty of curves, and you rarely see a straight stretch of track. The only double-tracked sections are commuter lines and the rail link from Oslo to Oslo Airport. Although Norway is described as having no high-speed trains, the airport link runs at speeds of up to 210 km/h. However, the same rolling stock is used for limited expresses on trunk lines with many sharp curves, causing the train to slow to less than 100 km/h and emit screeching from the bogies. There are 45° shock absorbers between the bogies and axle boxes and the axles appear to shift laterally as the train passes a curve. Needless to say, the ride comfort is poor but the upside is that you get an excellent view of the locomotive from the sixth carriage because the minimum curve radius seems to follow the 300-yard guideline recommended by Stephenson!

On the Isle of Man, I saw locomotives from the 1870s almost all manufactured by Beyer Peacock with leading bogies that are very similar to those once used in Norway. They now haul tourist trains and look very attractive with their brightly polished boilers. The 3' gauge is not a problem because the island line is not connected to any other. This further reduction in the width of narrow gauge from 3'6" to 3' shows how much rail technology advanced in the few years before the 1870s.

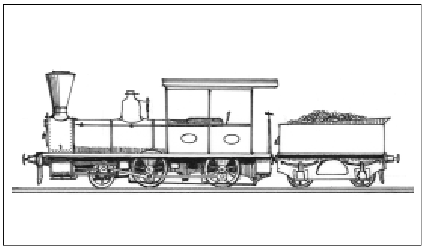
Norway's rail technology and locomotives came from Britain, so it is natural that the railway consultants in Britain's colonies were extremely interested in transportation developments there. Sir C. Fox served as a consultant in Australia and sent his son Douglas to Norway in 1864 to gather information. The information was put to good use the following year in Queensland.

New Zealand began laying track to the



Beyer Peacock (1866) 1-B locomotive in Norwegian Railway Museum (Author)

Another Beyer Peacock 1-B locomotive in operations since 1873 on the Isle of Man (Author)



Avonside (1865) locomotive in Queensland (Author)

Festiniog Railway's first B-locomotive buit in 1863 (Author)

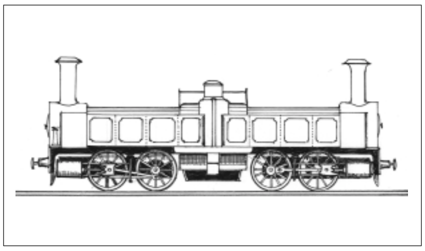
5'3" gauge from 1863 but all of it had been reduced to 3'6" by 1870. Similarly, standard-gauge track laid in Indonesia from 1867 was gradually changed to 3'6". The gauge-change took time and was only completed during Japan's wartime occupation.

Meanwhile, in England, lobbyists eager to take advantage of recent technical advances overseas began pressuring the government to permit narrow-gauge railway construction. One keen promoter of narrow gauge was the Duke of Sutherland who believed that the standard gauge was unsuitable for backward rural areas. The Duke was born and lived in London and seems to have had little interest in his landholdings in the County of Sutherland in northern Scotland. But he was very interested in railway development and became a central figure in rail circles, offering financial backing and consensus-making expertise.

Since the government prohibited construction of narrow-gauge main lines, public's attention turned to slate mines at Festiniog in Wales, where human or animal power was used to pull carts on narrow track (most no wider than 2'). Railway-related people at Festiniog decided to mechanize the track using steam locomotives.

A standard-gauge track belonging to a railway company already came close to the mine and mine owners feared that if the standard gauge reached near the mine track, the mine might end up in the hands of the railway company. The mine owners therefore decided to mechanize the mine railway themselves to guarantee access to the nearby port. In 1864, Festiniog Railway started operating on a 2' narrow gauge (600 mm) and was hauled by a B-locomotive. Before the mechanization, the mine carts had used gravity to roll downhill but had been hauled back up separately by horses. This was more strenuous work than hauling slate inside the mine because the elevation rose by 216 m over a length of 22 km. Developing a locomotive capable of pulling such a load up this grade on such a narrow gauge took 3 years.

Although Festiniog Railway advanced narrow-gauge technology, the railway only proved its potential after a Fairlie locomotive with special bogies was introduced in 1869. Just as interest in narrow-gauge railways was rising,



Fairlie locomotive with special bogies introduced in 1869 (Author)

Englishman Robert Fairlie (1831–85) demonstrated how the B+B steam locomotive he had invented could boost carrying capacity on the Festiniog Railway. But even Fairlie experienced considerable difficulty designing a locomotive for the 2' gauge at Festiniog and when he was later invited to the Rio Grande Railway in the United States his advice was to build no narrower than 3'. This was the origin of the 3' gauge in the United States.

Fairlie's locomotive had insufficient space to mount the valve gear inside, so he adopted the first Walschaert valve gear design in Britain. He had great difficulty before designing flexible high-pressure steam pipes to fit the bogie configuration. I took a good look and saw how he designed what looks like a rubber pipe covered in white cloth wrapped in a stainless-steel netting. Improvement in these materials offered a simple solution posed by steam at about 10 atmospheres. Fairlie's locomotive offered better stability and far superior performance and the double boilers were more than three times larger. These advantages plus the economic attraction of narrow gauge quickly attracted the public's attention and Fairlie was lionized in the *London Times* and other major newspapers. Countries with vast rural areas were also interested. In 1870, at the instigation of the Duke of Sutherland, the governments of Russia, India, France, Germany, Sweden and Switzerland sent numerous delegates to his Festiniog Railway to gather information on the new technology.

When I sat in the lobby of the old hotel in Portmadoc at the port once served by the Festiniog Railway, I could feel the excitement of those days—Fairlie's *Little Wonder* hauling a delegation in four cars with 90 empty freight wagons trailing behind. There is still a photograph of the scene and I walked along the line for about a third of its distance to the exact spot where the photographer had stood 130 years previously and took a picture from almost the same angle. Today, the same view complete with an exact replica of the locomotive painted the same reddish-brown can be seen among trees that have grown tall in the intervening years. Visitors enjoy seeing the locomotive chugging gallantly up the continuous grade of 10 to 15 per mill at more than 40 km/h.

In 1863, the same year that British railway engineers first became interested in narrow-gauge railway developments in Norway and the year that the 2' gauge Festiniog Railway began steam operations, Inoue left Japan in secret with four friends bound for England. They left in secret, because the Japanese Tokugawa Shogunate still banned foreign travel. Inoue studied civil and railway engineering at University College in London and returned to Japan in 1868 to become Japan's first railway expert.

His return coincided with the establishment of a new Meiji government that was eager to modernize the country. The government was convinced that railways were the best way to promote modernization and exert centralized authority throughout Japan. Inoue was in the right place at the right time.

While Inoue was studying in London, narrow-gauge railways were being constructed in one European colony after another and the media was praising railways and calling for more. In 1868, the year Inoue returned home, a special committee of experts met in England to promote the concept of a global network of cheap-to-build, narrow-gauge railways. After his return, Inoue must have heard of Fairlie's successful narrow-gauge locomotive. A new age had arrived—a time when narrow-gauge railways were being accepted by rail experts as an excellent way to bring

Working replica of Fairlie's *Little Wonder* double-boiler locomotive. The only difference from the original is the cab roof—the original did not have one. (Author)

Fairlie replica loco chugging gallantly up the continuous grade of 10 to 15 per mill at more than 40 km/h on the loop line at Duart just like the original 130 years ago. (Author)

Driver's cab of Fairlie replica loco (Author)

modern civilization to underdeveloped parts of the world.

At the end of the 1860s, who would have thought that Japan would become a major economic power? In those days, the government still had not come up with its strident 'Enrich the Country and Strengthen the Military' slogan. The cheap-to-build narrow gauge was probably the only option considered at the time. When the Norwegian government indicated that it was not going to invest in railway construction, local citizens raised the funds through bonds. On the other hand, Japan depended entirely on funds raised in England, so we can assume that the Japanese government was not in a position to consider any track other than narrow gauge. Inoue probably would not have thought anything better was possible.

Japan's topographical features permitted more gradual curves than in Norway, perhaps explaining why the 3'6" gauge was chosen over other even narrower gauges. Edmund Morel (1841–71), a British engineer hired by the Japanese government, conferred with Inoue and it is likely that these two men agreed on 3'6". Vice Minister of Finance Okuma had no first-hand knowledge of track gauges and surely had no option but to accept Inoue's recommendation.

Today's conventional (non-shinkansen) rail network does not have curves sharp enough to require narrow gauge and Norway's main lines have even sharper curves but the tracks are built to standard gauge. Clearly, it is safe to assume that Japan's choice of the 3'6" narrow gauge was based more on the cheaper construction cost than on the demands of topography. Norway gradually replaced its narrow gauge track with standard gauge but Japan did not take this road because of economic and military considerations.

There are still some loud complaints about the problems caused by Japan's adoption of the 3'6" narrow gauge but it is simplistic to say that if Japanese railways had switched to standard gauge they would have immediately enjoyed greater capacity and speed. I believe there would have been little improvement at least up until WWII. Norway's standard gauge track permits an axle load of only 15.5 tonnes and advanced locomotives have to deal with curves and gradients using 1.53-m driving wheels and four axles. A broader gauge does not offer substantial advantages unless the basic track configuration is improved.

Although Japan was strong militarily in the years leading up to WWII, the people's standard of living still placed it among countries that needed no more than a narrow-gauge railway.

It seems to me that Okuma and Inoue's choice of the 3'6" narrow gauge was just dictated by the times. ■

**Akira Saito**

Mr Saito is the Chairman of the Railway Society of Keio University Alumni. After graduating in 1957, he joined Nissan Motor Co., Ltd. where he became Representative Director of Obihiro Nissan and Managing Director of Autech Japan, Inc. Since retiring in 1994, he has been actively researching railway and steam locomotive history.