= Flåm Line =

The Flåm Line ( Norwegian : Flåmsbana ) is a 20 @.@ 2 @-@ kilometer ( 12 @.@ 6 mi ) long railway line between Myrdal and Flåm in Aurland , Norway . A branch line of the Bergen Line , it runs through the valley of Flåmsdalen and connects the mainline with Sognefjord . The line 's elevation difference is 863 meters ( 2 @,@ 831 ft ) ; it has ten stations , twenty tunnels and one bridge . The maximum gradient is 5 @.@ 5 percent ( 1 : 18 ) . Because of its steep gradient and picturesque nature , the Flåm Line is now almost exclusively a tourist service and has become the third @-@ most visited tourist attraction in Norway .

Construction of the line started in 1924 , with the line opening in 1940 . It allowed the district of Sogn access to Bergen and Oslo via the Bergen Line . Electric traction was taken into use in 1944 ; at first El 9 locomotives were used , and from 1982 El 11 . Until 1991 , the train connected with a ferry service from Flåm to Gudvangen . In 1992 , freight services were terminated , and due to low ticket prices and high operating costs , the line was nearly closed . In 1998 , Flåm Utvikling took over marketing and ticket sale for the line , prices were heavily increased and El 17 locomotives were introduced . The trains remain operated by the Norwegian State Railways ( NSB ) , while the line itself is owned and operated by the Norwegian National Rail Administration .

= = Route = =

The Flåm Line runs from Myrdal on the Bergen Line to Flåm . Myrdal Station is located in a mountain pass at 863 @.@ 6 meters ( 2 @,@ 833 ft ) above mean sea level ( AMSL ) , while Flåm is located at 2 @.@ 0 meters ( 6 ft 7 in ) AMSL . The line 's maximum gradient is 5 @.@ 5 percent , and 16 @.@ 1 kilometers ( 10 @.@ 0 mi ) of the line 's 20 @.@ 20 kilometers ( 12 @.@ 55 mi ) have at least 2 @.@ 8 percent gradient . The line has standard gauge and a minimum curve radius of 130 meters ( 430 ft ) , and is the steepest standard @-@ gauge railway in Europe . Maximum permitted speed upwards is 40 km / h ( 25 mph ) , while it is 30 km / h ( 19 mph ) downhill . The line has eight stops , twenty tunnels and one bridge . The line is electrified at 15 kV 16 2 ? 3 Hz AC using overhead wire , and is equipped with Global System for Mobile Communications ? Railway ( GSM @-@ R ) , but lacks centralized traffic control ( CTC ) . The infrastructure is owned and operated by the Norwegian National Rail Administration .

At Myrdal Station , the Flåm Line runs in the same direction as the trains towards Oslo , but immediately starts running downwards into the Flåmsdalen valley . The first part of the line runs through snow shelters and several short tunnels . Vatnahalsen Station is located 1 @.@ 13 kilometers ( 0 @.@ 70 mi ) from Myrdal , at 811 meters ( 2 @,@ 661 ft ) AMSL . The line then runs through a horseshoe curve and the 880 @-@ meter @-@ long ( 2 @,@ 890 ft ) Vatnahalsen Tunnel . It exits the tunnel onto an artificial shelf on a cliff which falls several hundred meters down . Reinunga Station is located 2 @.@ 20 kilometers ( 1 @.@ 37 mi ) from Myrdal and at 767 meters ( 2 @,@ 516 ft ) elevation . It is followed by Kjosfossen Station , 4 @.@ 40 kilometers ( 2 @.@ 73 mi ) from Myrdal and 670 meters ( 2 @,@ 200 ft ) AMSL , which serves no other purpose than allowing tourists to look at the waterfall Kjosfossen .

The line then runs through the 1 @,@ 341 @.@ 5 @-@ meter @-@ long ( 4 @,@ 401 ft ) Nåli Tunnel , the longest on the line . At the end of the tunnel lies Kårdal Station , traditionally serving the farm furthest up in the valley . The station is 6 @.@ 34 kilometers ( 3 @.@ 94 mi ) from Myrdal and 557 meters ( 1 @,@ 827 ft ) AMSL . On the other side of the valley is Trodlatoppen , the site of several avalanches every year . The line then runs through the 1 @,@ 029 @-@ meter @-@ long ( 3 @,@ 376 ft ) Blomhelleer Tunnel , after which it reaches Blomheller Station , 8 @.@ 40 kilometers ( 5 @.@ 22 mi ) from Myrdal and 458 meters ( 1 @,@ 503 ft ) AMSL . The railway then crosses the river Flåmselvi and runs through a series of short tunnels .

At 10 @.@ 51 kilometers ( 6 @.@ 53 mi ) from Myrdal , the line reaches Berekvam Station , located at 344 meters ( 1 @,@ 129 ft ) AMSL . It is the only station to have a passing loop and thus the only location on the line where trains can meet . Because the station is unmanned and lacks CTC , crossing must be performed using flags at day and torches at night , set by personnel who

travel from Myrdal or Flåm . At Høga , the railway crosses the river again , this time by the river running in a tunnel under the tracks . The next station is Dalsbotn Station , located 13 @.@ 90 kilometers ( 8 @.@ 64 mi ) from Myrdal and at 199 meters ( 653 ft ) AMSL . Just before reaching the last tunnel , the 424 @-@ meter ( 1 @,@ 391 ft ) long Furuberget Tunnel , the line passes by the waterfall Rjoandefossen , which with a 140 @-@ meter ( 460 ft ) vertical drop is one of the line 's main attractions .

After Håreina Station , located 17 @.@ 21 kilometers ( 10 @.@ 69 mi ) from Myrdal at 48 meters ( 157 ft ) elevation , the valley widens and changes character , becoming flatter and with more vegetation . After passing Lunden Station , 18 @.@ 60 kilometers ( 11 @.@ 56 mi ) from Myrdal and at 16 meters ( 52 ft ) elevation , the line reaches the terminus , Flåm Station . Located on Aurlandsfjord , a branch of the Sognefjord , Flåm has 400 residents and is nearly exclusively a tourist area , featuring amongst other things a hotel and a cruise ship port . The station also has a railway museum dedicated to the Flåm Line .

= = History = =

= = = Planning = = =

Plans to build a railway to connect Norway 's two largest cities , Oslo and Bergen , were launched by Andreas Tanberg Gløersen in 1871 . He proposed that the line run via Hallingdal and Voss and include two short branch lines which would connect to the two major fjord systems in the area , Sognefjord and Hardangerfjord . The narrow gauge Voss Line from Bergen to Voss opened in 1883 , and the Bergen Line was completed as standard gauge in 1909 . During the construction of the Bergen Line , the path that ran up Flåmsdalen was upgraded by NSB to allow access to the area around Myrdal . The Hardanger Line , which connected the Bergen Line to Hardangerfjord , opened in 1935 , and was the country 's first railway to open with electric traction .

The first engineering surveys for the Flåm Line were performed in 1893 . It resulted in a proposal for a 1 @,@ 067 mm ( 3 ft 6 in ) narrow gauge railway which would be 18 @.@ 0 kilometers ( 11 @.@ 2 mi ) long . Most of the railway would be built as an adhesion railway with a 2 @.@ 5 percent gradient , although part of it would be a rack railway with a gradient of 10 @.@ 0 percent . It was at the time estimated to cost 3 @.@ 3 million Norwegian krone ( NOK ) . In 1904 , a radically different route to Sognefjord was proposed : a 47 @.@ 13 @-@ kilometer ( 29 @.@ 29 mi ) long adhesion line from Voss to Gudvangen via Stalheim . It was estimated to cost NOK 3 @.@ 5 million , but was considered by local politicians to be inferior to the Flåm alternative . A third alternative was a combined tramway and funicular , which would be built between Myrdal and Fretheim . It was estimated to cost NOK 800 @,@ 000 , but NSB was concerned that the proposal 's light rolling stock would not be sufficient to operate through snow during the winter . Estimated traffic for the Flåm Line was 22 @,@ 000 annual passengers .

As both the other alternatives were discarded , consensus gradually grew for the Flåm alternative , and the Railway Committee for Nordre Bergenhus County recommended this proposal . New plans from NSB criticized the mix of rack and adhesion railway , and instead proposed a conventional adhesion line all the way . Engineer Ferdinand Bjerke traveled to Continental Europe to study several combined railways . He published a preliminary report in 1911 , which recommended an adhesion railway , although he also felt the need for a detailed study of a rack railway . His final report was finished in 1913 , and although it recommended adhesion , it pointed out that the line 's capacity would be smaller than predicted and that costs would be three times as high ? NOK 5 @.@ 5 million . The plans were approved by the Ministry of Labour and NSB 's main board in 1915 .

The plans were approved by Parliament in 1916 . However , the decision concerning technical specifications was not taken by Parliament until 1923 , when it decided that the line was to be electric . The line was then estimated to cost NOK 14 @.@ 5 million ? the increase caused by inflation during the First World War ? of which NOK 1 @.@ 2 million was to be paid by the local governments . The line was to have tracks which weighed 25 kilograms per meter ( 50 lb / ft ) . The

curve radius was set to minimum 150 meters ( 490 ft ) , although exceptionally 125 meters ( 410 ft ) was permitted . The steepest permitted gradient was 5 @.@ 5 percent ( 1 : 18 ) .

In 1915 , the first proposal was launched for using a bus service as an alternative to the train . This was rejected because buses were not able to give the comfort and reliability of a train . The idea was proposed again in 1922 by the director of the Norwegian Public Roads Administration . Among the strongest opponents to the bus alternative was Ingolf Elster Christensen , County Governor of Sogn og Fjordane and later parliamentarian , who stated that the Nordre Bergenhus County ( today Sogn og Fjordane County Municipality ) had paid part of the regional financing of the Bergen Line on condition that they receive a branch line to the Sognefjord .

The 1920s saw high inflation and large public deficits . Several public committees were created solely to cut costs . One such proposal was to build a road to Flåm , with the proposal being led by Hans Kristian Seip , who was director of Bergen Public Road Administration . In 1925 , following the appointment of Mowinckel 's First Cabinet , it was proposed that the railway be built as a road , and the tracks laid later . One of NSB 's board members proposed instead building a suspended railway . The plans to cancel the railway were stopped because of parliamentarian support for the railway . Part of the political support was because there was agreement on a national railway plan , and removing parts of it would disrupt the geographical compromise . However , Parliament did vote to reduce the number of intermediate stations to one , which would allow trains to meet at Berekvam . The cost saving for a road was estimated at 30 percent . The issue of a road was taken up in a new vote in Parliament in 1927 , but was again rejected .

= = = Construction = = =

The administration office for the construction was established in 1923 and was until 1935 located at Voss . In that period , construction was led by Peter Bernhard Kristian Lahlum , who was also responsible for the Hardanger Line . After the Hardanger Line was completed , Lahlum retired , and the office was moved to Flåm where responsibility was taken over by Adolph M. B. Kielland . To start with , there were 120 men working on the construction , although this quickly increased to 220 . The numbers fluctuated between that and as low as 80 , although hit an all @-@ time high of 280 people in 1937 . To house the employees , eight barracks were built . Among the first things built were housing and station buildings , which could then be used by people working on the construction . The local economy was stimulated by farmers being paid for transport . Using horses , they would transport tourists by day and building materials by night . The competition was fierce , resulting in fights for customers , although it calmed down after traffic police were introduced .

In 1924 , there was a landslide at Høga , covering the area planned for the railway . The area was made of phyllite and was the geologically most unstable area on the route . The initial response was to plan for a tunnel past the area , but this was quickly rejected because of the high price . Instead , the line was moved further away from the mountain side . Other slides during construction included an avalanche near Store Reppa on 10 February 1925 , which deposited up to 3 @.@ 5 meters ( 11 ft ) of earth . In April 1925 , a 1 @,@ 000 cubic meters ( 35 @,@ 000 cu ft ) landslide took place above Berekvam . On 8 February 1928 , an avalanche did some damage to the right @-@ of @-@ way near Nåli .

The tunnels were the most difficult and time @-@ consuming part of construction . Of the twenty tunnels , machines were only used for the Nåli and Vatnahalsen Tunnels ? the rest were built by hand . Hand @-@ construction was done by drilling up to 4 @.@ 2 meters ( 14 ft ) through the rock , filling the holes with dynamite and blasting . Construction of tunnels started in 1924 and the first tunnel was completed in 1926 ; the last tunnel was completed in 1935 . On average , tunneling proceeded at between 116 and 180 man @-@ hours per meter ( 35 ? 55 hr / ft ) . The work caused death or lifelong respiratory problems through silicosis caused by inhaling the smoke . There were two fatal accidents , one in 1925 and one 1938 , both related to tunnel work .

Ten stations were built for the line , including a major upgrade to Myrdal and port facilities at Flåm . Myrdal Station was given side tracks and additional buildings to serve transferring passengers , with the upgrades costing NOK 0 @.@ 5 million . Breikvam was the only place on @-@ route which

received a passing loop . Flåm Station cost NOK 0 @.@ 8 million and was designed in the 1930s NSB simple wooden functionalist style , similar to what is found on the Nordland Line and the Sørland Line . Other stations received small , wooden buildings with a waiting room , as well as a room for cargo at Vatnahalsen , Håreina and Dalsbotn .

Laying of tracks started in 1936 , and was assisted by two steam locomotives . The work started at Myrdal and reached Reinunga the first year , Kjosfossen Tunnel the second year and the Blomheller Tunnel in 1939 . The first train to operate on a regular schedule was in October 1939 , when a freight train between Myrdal and Berekvam ran three times a week . However , this service was stopped by the end of the month . With the German occupation of Norway in 1940 , work started later in the season , but the German authorities wanted to speed up the work to make the line usable for steam trains that same year . They scheduled the line for completion in 1942 . Track laying work was accelerated by increasing the number of workers from 58 to 195 . Regular freight operation on the Flåm Line started on 1 August 1940 , albeit limited to an axle load of 12 tonnes ( 12 long tons ; 13 short tons ) . At the time there were four trains each day , two in each direction .

Passenger trains started running on 10 February 1941 , also with two trains in each direction per day . Travel time was 65 minutes downhill and 80 minutes uphill . The official name of the line was decided by the ministry on 26 June 1941 . From 1 May 1942 , Rolf Aksnes took over as head engineer after Kielland . During construction of the Bergen Line in 1898 , the upper part of Kjosfossen had been built up with a hydroelectric power station . Another power station was built there , and taken into use on 27 October 1944 . Built by Kværner and Norsk Elektrisk & Brown Boveri ( NEBB ) , it had a power output of 1 @,@ 700 kilowatts ( 2 @,@ 300 hp ) .

The costs for the project ended at NOK 26 @,@ 651 @,@ 900 , of which NOK 22 @.@ 0 million was for the railway . This total included NOK 2 @.@ 3 million for a power station and NOK 1 @.@ 2 million for a ferry quay at Flåm . The largest cost was for earthwork , which ended at NOK 9 @.@ 1 million ; other major costs were NOK 2 @.@ 4 million for rolling stock , NOK 1 @.@ 6 million for stations , NOK 1 @.@ 2 for tracks , NOK 1 @.@ 5 million for snow protection and NOK 675 @,@ 000 for electrification .

= = = Operation = = =

Regular operation with electric locomotives was introduced on 25 November 1944 . To begin with , Class 64 railcars were used . NSB had originally planned to use electric multiple units , but changed the plans during the war and instead decided to use locomotives and cars . The Class 64 trains remained in service on the Flåm Line until May 1947 . They were normally used on the Hardanger Line , but were regularly taken back into use on the Flåm Line when the traffic was at its lowest .

NSB ordered three El 9 locomotives from Thune on 4 October 1940 . The units were delivered in 1942 , with the electrical components from NEBB and the transformers and controllers from Per Kure . A delay was caused by bombing of Per Kure by the resistance . The locomotives were custom @-@ built for the steep gradients on the Flåm and Hardanger Lines , and were delivered with an axle load of 12 tonnes ( 12 long tons ; 13 short tons ) and a Bo 'Bo ' wheel configuration . The locomotives weighed 48 tonnes ( 47 long tons ; 53 short tons ) and the maximum permitted train weight was 85 tonnes ( 84 long tons ; 94 short tons ) . If the trains were to stop at Kårdal , the weight was further limited to 65 tonnes ( 64 long tons ; 72 short tons ) .

Initially there were three trains on the Bergen Line in each direction per day , so only a single locomotive was necessary on the Flåm Line . From 1949 there were two locomotives on the Flåm Line and from 1955 all three were used there . Five passenger cars in aluminum were delivered by Strømmens Værksted . The cost of the three locomotives and five cars was NOK 2 @.@ 4 million .

The railway quickly saw an increase in traffic , with an average 11 percent annual increase from the opening until the mid @-@ 1950s . In part to allow access to Kjosfossen , Kjosfossen Station was opened in 1951 . By then , ridership had stabilized at 115 @,@ 000 people per year . A significant portion of the traffic consisted of tourists , in part from cruise ships docked in Flåm . In the latter half of the decade , NSB launched the Norway in a Nutshell package , which included a ride on the Flåm Line . A sleeping car was introduced on the night train between Flåm and Oslo in 1958 . It made

three trips in each direction per week during the summer season , and achieved an 84 percent occupancy rate . The same year , Breikvam Station became unmanned . Traffic remained stable throughout the 1960s , while interest in developing the railway for tourists declined and local politicians stated that a road was needed to attract tourists to Aurland . The power station was upgraded to 14 @,@ 000 kilowatts ( 19 @,@ 000 hp ) in 1969 .

In 1969 , ridership increased by 10 percent and by 12 percent the following year . In 1971 and 1972 , it saw a 20 @-@ percent increase ? the latter representing the first year with InterRail tickets . By then the annual ridership had reached 175 @,@ 000 . In 1970 , an additional train was stationed at Flåm , which made it possible to travel a round trip between Flåm and Bergen in a day . Between 1975 and 1982 , NSB started running direct trains between Ål and Flåm . In 1978 , the morning express trains on the Bergen Line started stopping at Myrdal , allowing better access for tourists to the Flåm Line . Traffic increased further until 1980 , when it hit 200 @,@ 000 , and then remained stable through the decade .

When the line opened , it received a lot of freight traffic for the construction of a power station in Årdal . From the opening , the Flåm Line was the fastest means of transport between Sogn and both Oslo and Bergen , and most post was also sent via the line . From 1977 , most of the post was instead sent by truck via Gol , and only post from Aurland went via the railway . Other products sent by the line were milk to the dairy in Voss , which terminated in 1983 , as well as fruit . Partial loads saw a large increase during the 1960s , after NSB and the ferry operator Fylkesbaatane i Sogn og Fjordane teamed up to send packages via Flåm to Oslo and Bergen . Flåm had several arrivals until 1973 , when Linjegods was established . Following a reorganization , the number of calls was reduced to once per week . Freight volume fell further during the 1980s ; an attempt in 1978 to force the three major distributors Linjegods , Firda Billag and Sogn Billag to route traffic via the Flåm Line failed .

During the 1970s , NSB started the process of finding a replacement for the El 9 . New locomotives would cost NOK 20 million , and the company saw it as unrealistic to invest so much in a marginal branch line . NSB had also concluded its away @-@ with @-@ the @-@ steam program , and therefore had a lack of locomotives in general . If a new class of locomotives was to be built , it would have to satisfy more than the requirements for the Flåm Line , so NSB instead started investigating whether any of the older models could be used . Tests were performed in 1971 and 1973 with El 11 , built between 1951 and 1964 , and El 13 , built between 1957 and 1966 . Neither was considered optimal : El 11 allowed the train weight to increase to 100 tonnes ( 98 long tons ; 110 short tons ) , but the train had the steps for the voltage regulator and the commutation set for too high speeds . El 13 had rheostatic brakes , which were not suitable for the gradient ; the locomotives were also better suited for mainline service and would therefore not be prioritized for branch lines .

In 1972 , the Flåm Line was rebuilt to allow an axle load of 18 tonnes ( 18 long tons ; 20 short tons ) . El 11 was chosen as El 9 's replacement in the mid @-@ 1970s , but it was not until November 1980 that El 11 @.@ 2098 started being rebuilt for its new service . Upgrades included rheostatic brakes and electromagnetic brakes , new speed measurement and curve lights . The locomotive was taken into use on the Flåm Line in June 1982 . A year later , El 11 @.@ 2092 was also taken into use after a similar rebuild . El 9 remained in sporadic use until 1989 . Class 69 electric multiple units were taken into use starting on 10 August 1982 . These had been allocated to Bergen District for use on the Bergen Commuter Rail , and were also used on the direct trains between Bergen and Flåm . The main disadvantage with the class was the small windows , as the trains were designed for commuter traffic rather than sight @-@ seeing .

In 1990 , a fast ferry service was introduced in Sogn with direct services to Bergen . In 1991 , the Gudvangen Tunnel opened , giving Flåm a road connection to Gudvangen and terminating the ferry service . NSB was losing money on the line , in part because of very low revenue per rider . The same ticket prices were charged as elsewhere , based on a fee per kilometer ; the low speed combined with a lot of free travelers using InterRail tickets gave little revenue . From 1991 , the ticket prices were increased as if the line was 20 kilometers ( 12 mi ) longer . In 1992 , a new station building was taken into use at Flåm . During the 1990s , X10 commuter trains from Stockholm were

borrowed during the summer for extra trains . These trains had larger windows than Class 69 , giving better views . A museum and documentation center was established in 1995 . Originally located in an annex of Fretheim Hotel , it moved in 1999 to the old station building at Flåm .

In March 1997 , NSB announced that they had plans to privatize the operations of the line from 1998 . The responsibility for setting the schedule , selling tickets and marketing was transferred to Flåm Utvikling , a newly established company that NSB owned 49 percent of , and Aurland Ressursutvikling 51 percent . The latter was owned by Aurland Municipality , the Industrial Development Corporation of Norway and Aurland Sparebank , a local bank . Flåm Utvikling also took over responsibility for other tourism @-@ related activities in Flåm , such as port facilities . NSB would still operate the trains , and Flåm Utvikling would pay NSB the cost of running the trains , but keep the profits from the ticket sales . The Norwegian National Rail Administration , which had been established in 1996 and had taken over the responsibility for infrastructure , retained ownership of the line itself . Flåm Utvikling also started building a cruise ship terminal at Flåm , so tourists could walk ashore and directly to the trains .

With the change of ownership , NSB also decided to replace the aging El 11 with El 17 . The locomotives had been delivered in 1987 and were intended for express train service , but had been plagued with technical problems and were not considered reliable enough to operate as single locomotives . The six newest trains of the class were painted in a new green livery and branded as Flåmsbana rather than NSB . Older B3 carriages were renovated , given new panorama windows and painted in the same color scheme and taken into use on the line . In October 2000 , NSB sold its shares in Flåm Utvikling to Aurland Ressursutvikling . The line received GSM @-@ R from 1 May 2005 . The same year , Nærøyfjord , the neighboring fjord to where Flåm is located , was inscribed as a World Heritage Site .

= = Service = =

The line is solely served by a tourist @-@ oriented service operated by the Norwegian State Railways on behalf of Flåm Utvikling . From May through September , there are nine or ten departures in each direction per day . In the rest of the year , there are four . Fares do not follow the normal fares for NSB and are considerably higher than on other train routes . InterRail tickets are not valid for free travel , but give a 30 percent discount . Travel time varies between 50 and 59 minutes between the end stations . In 2007 , the line was the third @-@ most visited tourist attraction in Norway and carried 547 @,@ 000 passengers in 2010 . The service is provided by push ? pull trains consisting of an El 17 at each end and with B3 carriages . The locomotives were built by Henschel in 1987 , with electrical equipment from NEBB . They have a power output of 3 @,@ 000 kilowatts ( 4 @,@ 000 hp ) and a Bo 'Bo ' wheel arrangement .