Norwegian Public Roads Administration
Operations and Maintenance
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Statens vegvesen

Evaluation report on testing of electric snow clearing

Evaluation report

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Background

The Norwegian Public Roads Administration (NPRA) aims for a 55 % reduction in CO2 emissions from its own activities by 2030. For operation and maintenance (O&M) contracts, snow clearing is one of the most energy-intensive tasks, and one of the tasks that cause the largest emissions of greenhouse gases.

All O&M contracts that start before September 2025 will be running at least until August 2030 before they are renewed. It is probably not realistic to expect that these contracts as a whole will have the technology or operational arrangements to ensure a 55% reduction in emissions from the contract projects. To achieve the goal of a 50 per cent reduction by 2030, contracts entered into after 2025 must therefore manage a reduction in emissions of more than 50 per cent. The NPRA believes that it is not possible to achieve the emission targets for 2030 without using zero-emission technology.

The NPRA therefore wants to test electric lorries to see whether they are suitable for snow clearing, and whether it is necessary to adapt contract requirements to facilitate the use of electric vehicles for snow clearing.

Choice of vehicle

One of the key objectives of the test was to test a lorry with sufficient battery capacity to carry out snow clearing over long periods of time. It was therefore decided to use a lorry manufactured by Designwerk. Litra AS had purchased two of these lorries, and the NPRA chose to rent one of these to carry out the experiment.

Technical vehicle data

- 1017 kWh battery (net 864 kWh)
- 500 kW / 680 HP
- Lithium-ion (NMC)
- System power output 400 V
- 44 kW AC on-board charger and 350 kW DC fast charging (CCS type 2: 800V)
- Total weight 21.6 t, plough included

The vehicle in question had a disposable battery capacity of 864 kWh (gross 1017), which could be charged with an output of up to 350 kW. The vehicle was a tractor unit, with one of its battery packs behind the driver's cab and one underneath the vehicle. It was in principle not ideal to have a battery pack underneath a vehicle used for snow clearing since this would eliminate the possibility of a centrally mounted blade. Since the purpose of this test was to measure the vehicle's range for snow clearing, it was still considered acceptable to carry out the test with this vehicle.

In order for the vehicle to be able to carry out snow clearing, it had to be modified to be able to install the necessary snow clearing equipment such as a plough, as well as extra weight plates to achieve sufficient ground pressure. It was also decided not to use spreading equipment on this lorry. Installation of spreading equipment

would have taken more time, and the time the NPRA had the vehicle at its disposal was limited. With spreading equipment, the vehicle will use more energy than without. It is estimated that spreading equipment would reduce the range by about 10-15 percent.

Choice of test road

The E6 over Dovrefjell (from Dombås to Grønbakken) was chosen as the main test road. This was to ensure that there was a sufficient amount of snow during the snow-clearing tests, as well as to be able to test the vehicle when clearing snow on long climbs. The E136 road from Dombås to Bjorli was also used as a secondary test road to collect as large amounts of data as possible. A number of tests were also carried out at the NPRA's test station at Bjorli, as well as one test on the Rv15 over Strynefjellet.

The location of Dovrefjell also made it possible to have access to publicly available chargers with high power on both sides of the mountain. Charging during the tests would have to be carried out at publicly accessible charging stations.

Organisation of the tests

The NPRA was responsible for the test itself, i.e. a test team from the NPRA followed up the test and carried out the necessary analyses. During the testing period, the vehicle was driven by drivers from SBM, which is also the O&M contractor for the selected road section. CHS Nor has assisted the process both with regard to procurement of vehicles and in terms of expertise before and during the test. The vehicle was rented from Litra AS.

During the test, the vehicle was actively used by the O&M contractor to carry out snow-clearing tasks on the E6 over Dovrefjell, but also on the E136 to ensure as large amounts of data as possible from the vehicle. Data collected on these snow-clearing drives form the basis for the analysis of the results of this test.

The plan was also to carry out a test over a two-day period at the NPRA's test station at Bjorli airport where there is 50-60 cm of compact snow. The purpose of this test was to measure the vehicle's capacity to perform the heaviest snow-clearing tasks and measure its energy consumption during the performance of these.

The testing itself had a duration of approximately one month, starting on 27 January 2024 and ending on 25 February 2024.

Important prerequisites

To ensure that the test did not create unforeseen operational disadvantages, the vehicle which is normally used for operation on this road was available and on standby throughout the testing period. This was to ensure that the vehicle could be quickly deployed to site in the event of a stop or breakdown of the test vehicle.

As a preventive measure, a wind speed limit of 20 m/s was also introduced for the use of this vehicle. At wind speeds above this level, the contractor was not to use this vehicle at Dovrefjell, but rather use it on the E136.

All charging of the vehicle was carried out at publicly accessible charging stations. To maintain heating of the battery pack, the vehicle was also connected to a 230V power supply when it was not out on a snow-clearing mission.

Weather during the testing period

The temperature during the testing period varied between 0 and -30 °C at Dovrefjell and on the E136. There were several days of precipitation during this period, but fewer than would have been ideal for this test. The number of precipitation days was nevertheless sufficient to be able to carry out the test and obtain sufficient amounts of data.

At Dovrefjell, the precipitation intensity was somewhat low, and the snow-clearing tasks the vehicle was used for mostly involved clearing away drifting snow and straightening up ploughed snowbanks. During the testing period, the vehicle was driven approximately 2,000 km, of which around 70% was for active snow clearing with a lowered plough, and 30% for transport without clearing snow, with the plough raised.

Results from tests at the Bjorli Airport test station

The NPRA has a test station at Bjorli, which consists of a runway at a disused airport. At the test station, the following tests were carried out:

- Opening of a closed "road" after snow storms, using a pointed plough
- Clearing compacted blown snow from the runway using a diagonal plough
- Snow clearing on an ordinary road using a diagonal plough
- Clearing snow along ploughed edges using diagonal and pointed ploughs (straightening up ploughed snowbanks)
- All tests were carried out at a speed of 35-45 km/h

The average energy consumption for the entire testing at the Bjorli test station was approximately 4.36 kWh/km. This also includes tests involving removal of 50-60 cm of compact and hard snow from the runway. The latter operation had an abnormally high consumption of 26.25 kWh/km. Apart from this operation, the average consumption was about 3.6 kWh/km for the test. This makes the estimated range approximately 240 km.

At the test station, the energy consumption for all operations separately and collectively was higher than the results recorded from the tests at Dovrefjell and on the E136. This is probably due to a combination of the fact that the test distance at the test station is short (800 m), and the fact that part of the operations involved removing compact snow and ice, which was laid out on the runway with a snowblower. Unusually large snow depths also made the vehicle use more energy on propulsion than what would have been the case for a road with a thin snowpacked layer.

The purpose of the test at the test station was not to simulate normal conditions as they would be on ordinary roads, but to test the vehicle under very demanding conditions. For example, if high mountain roads are to be opened after a long period of snowstorms. The result from this test must therefore be considered an absolute minimum of what the vehicle is able to deliver in terms of range for demanding snow-clearing jobs.

When assessing the results, it must be assumed that electric vehicles will normally limit charging to 90 per cent of the battery's total capacity (SOC) and not go lower than 10 per cent before the vehicle needs to charge. The estimated range for the interval 90-10 percent will therefore be 192 km.

192 km of snow clearing under similarly demanding conditions will therefore allow snow clearing for at least 6.4 hours non-stop for the 90-10 battery interval.

Results from tests on the E6 over Dovrefjell and on the E136

Throughout the testing period, the vehicle was used in ordinary operation and a diagonal plough was used for snow clearing.

The average energy consumption for the entire test was 1.56 kWh/km. This includes snow clearing in different types of weather conditions with varying amounts of precipitation. Temperatures during the tests have varied between around 0 and -30 °C. The highest recorded consumption for snow clearing on roads is 1.82 kWh/km.

A consumption level of 1.56 kWh/km makes the estimated range 554 km. The estimated range for the interval 90-10 percent is 443 km. This indicates that the

vehicle will be able to clear snow for up to 14.7 hours non-stop for the battery interval 90-10 percent.

With a consumption of 1.82 kWh/km (the highest recorded consumption during snow clearing on roads), the estimated range will be 380 km for the 90-10 percent interval. With such consumption, the vehicle will be able to clear snow for up to 12.6 hours non-stop.

Suitability of the vehicle on roads in operating category DkC and charging speed

All roads that are the NPRA's responsibility are divided into operating categories. These categories set requirements for approved driving conditions and response times when there are weather events. Both the E6 over Dovrefjell and the E136 are in operating category DkC. It is one of the most common operating categories in Norway, where approved driving conditions are bare roads (dry or wet) in mild weather periods and hard snow/ice in cold weather periods.

Snow-clearing cycle time for roads in operating category DkC is 2.5 hours. With a consumption of 1.82 kWh/km, the vehicle will use 136.5 kWh of energy on one cycle. To supply the battery with 136.5 kWh of energy, the vehicle must charge for around 25 minutes at an output of 350 kW (assuming 5% charge loss). This means that a 25-minute charging stop after each cycle can provide the vehicle with sufficient energy to carry out continuous snow clearing.

With a charging stop of around 11 minutes after each cycle, the vehicle may be able to carry out snow clearing for at least 24 hours before the SOC <10 percent. This is if start-up is at a SOC > 90 percent. The same result is also possible to achieve by charging for 22 minutes after every other cycle.

Most of the charging during the test was carried out at the Ionity charging station at Dombås. The charging tests show that the vehicle achieves a charging speed of 350 kW and the output remains around this level throughout the charging session.

The NPRA has a standard of operation that requires vehicles to be in continuous operation in order to comply with the requirements of the contract, if the contractor chooses to let their snow-clearing patrol sections have the maximum permitted length.

Contractors who want to use electric vehicles for snow clearing can, according to contract, meet the current requirements by having shorter section lengths so that the vehicle will have sufficient time to charge within the applicable cycle time. Shorter section lengths may also result in the need for more vehicles. The NPRA must consider how this can be avoided, for example by making minor adjustments to the contract's requirements for cycle time and/or requirements regarding how to determine section lengths. Such adjustments will not necessarily affect the quality of snow clearing or reduce accessibility and traffic flow.

In the NPRA's contracts, the snow-clearing speed must be 30 km/h when determining the length of snow-clearing patrol sections, while the maximum permitted speed while clearing snow is 40 km/h. For sections where it is possible to clear snow at an average speed of approx. 35-40 km/h, it is possible to fast-charge after each drive and at the same time stay within the cycle time of 2.5 hours for roads in operating category DkC. The snow-clearing patrol section that the E6 over Dovrefjell belongs to can therefore be ploughed electrically within the current cycle time requirements, without any adjustments to the cycle time requirements.

Summary

The results of the test show that, with minor adjustments to the contract requirements, we can facilitate the use of electric vehicles for snow clearing without this entailing a need for more vehicles or a significant change in the quality of the winter maintenance road users will encounter.

In normal operation, the O&M contractor will rarely need to clear snow for so long that there is a need to charge the vehicle between snow-clearing drives (snow-clearing cycle). As long as the O&M contractors are able to use depot charging at 50-90 kW, this will be enough for most of the snow-clearing activity. Therefore, the access to depot charging should be considered in operating contracts where electric snow-clearing vehicles are to be used.

In Innlandet County, it is estimated that the O&M contractor needs to clear snow with the same vehicle for more than 24 hours in a row only 2-3 times during a winter season. The need for charging stops during snow clearing will therefore be limited as long as the vehicle starts with sufficient battery capacity. Most snow-clearing operations last less than10 hours, which is well within what the vehicle is able to deliver in terms of operating time for active snow clearing.

Actual energy consumption and charging needs will vary with a number of factors such as precipitation and temperature. In order to assess the vehicle's suitability, we based our assessments of the result on the highest registered consumption from the tests on the E6 over Dovrefjell and the E136. If we had based them on average

energy consumption, the results would have been significantly better. Since one of the objectives of the test was to find out whether electric vehicles can be used in our contracts, we chose to use the highest registered consumption as a basis to avoid overly "optimistic" results.

We also did not register during the tests any significant reduction in range due to low temperatures. Even in temperatures down to -30 °C, the vehicle had a very limited loss of range. This is because the battery pack is kept heated to between 15-20 °C at all times. A compact battery pack also means that little energy is used to keep the battery warm.

The tests at the Bjorli test station showed that the electric snow-clearing vehicle performs well even in very demanding winter conditions with large amounts of snow, compact snow, and low temperatures.

The results of the tests show that the technology has developed sufficiently for electric vehicles to be used in the NPRA's contracts. Minor adjustments to the contract's requirements will also help facilitate the use of electric vehicles for snow clearing in a safe and efficient manner.