

An aerial photograph of a parking lot filled with semi-trucks. The trucks are parked in neat rows, and their colorful cabs (red, blue, green, purple) are visible against the white trailers. The perspective is from directly above, looking down at the vehicles.

NEXT NORDIC GREEN TRANSPORT WAVE - LARGE VEHICLES

Nordic transport regulations for large-scale
hydrogen transport

Deliverable 2.3
December 2020



Nordic
Innovation

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Next wave - about the project

Electrification of the transport sector already began and the Nordic countries, specifically Norway and Iceland, have taken major steps resulting in battery electric vehicles (BEVs) already accounting for a substantial percentage of the total sales. The world is looking towards the Nordics as they are providing global examples for success. However, little is happening regarding larger vehicles as battery solution still are not able to provide heavy-duty users (e.g., buses, trucks, and lorries) the mobility they need.

Fuel cell electric vehicles using hydrogen as a fuel can solve this. The project focuses on providing infrastructure for a large-scale deployment of trucks, buses, and lorries. The goal is to further stimulate the global technological lead, which the Nordic countries have by stimulating the very first hydrogen infrastructure roll-out for larger vehicles while at the same time map how the infrastructure build-up needs to be done, so that the transition to hydrogen vehicles can happen smoothly. Such roll-out will also benefit the use of hydrogen for trains and the maritime sector. Furthermore, in addition of sourcing the hydrogen as a by-product from the industry, in the Nordic region we have the unique opportunity to produce the hydrogen in a green manner exploiting renewable electricity production.

Already, Nordic industries have taken international lead in the field of hydrogen and fuel cells and a unique cooperation exists between "hydrogen companies" via the Nordic Hydrogen Partnership (former Scandinavian Hydrogen Highway Partnership, SHHP) cooperation. Jointly they have marketed the Nordic platform for hydrogen and, at the same time, paved the way for vehicle manufacturers to deploy such vehicles in the Nordic countries. When it comes to hydrogen, the Nordics have globally leading companies both within the infrastructure and the fuel cell business. The project therefore sets forward four key activities in a unique project where technical innovation and deployment strategies are intertwined.

The project will deliver an analysis on large-scale transport of hydrogen with mobile pipeline, a description of the innovation and business potential for a roll-out of FC-buses in the Nordic region, as well as a coordinated action plan for stimulating the FC truck demand and a prospect for utilising hydrogen in heavy-duty equipment. Finally, the project will contribute to national and Nordic hydrogen strategy processes even providing input to a possible Nordic Hydrogen Strategy.

Partners in Next Wave:



Authors:

Name of author, contributors company/ organization

VTT: Jari Ihonen

Hydrogen Sweden: Anna Grzelec, Erik Wiberg, Björn Aronsson

Icelandic New Energy: Jón Björn Skúlason

Hydrogen Denmark: Eleonore Fenne

Norwegian Hydrogen Forum: Ingebjørg Telnes Wilhelmsen

Kunnskapsbyen Lillestrøm Norway: Jon Eriksen

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Summary

As discussed in Next Wave Deliverable 2.1, in Sweden, Norway, and especially in Finland, there is hydrogen available as by-product from industrial processes which could be used as transportation fuel after additional purification.

In all Nordic countries, current fossil fuel-based hydrogen production in industry may be replaced by large-scale production of renewable hydrogen produced by electrolysis. There are also major new plans to increase hydrogen production and use in industry in all Nordic countries, as reported in Next Wave Deliverable 2.2. The excess hydrogen production capacity from these sites could be used for hydrogen production for transportation purposes.

When hydrogen produced in these centralised locations is transported to hydrogen refuelling stations (HRS), which have no hydrogen production of their own, a semi-central hydrogen supply chain (HSC) is applied. This HSC mode has been assumed in a recent hydrogen truck study¹. Especially by-product hydrogen can also be transported for industrial users to replace existing hydrogen production or fossil fuels in heat production.

In this deliverable, the most important boundary conditions for hydrogen transport from centralised production plants to HRS or industrial users are analysed for each Nordic country. The two most important boundary conditions are: 1) local regulations for the maximum length and weight of the trucks carrying the hydrogen, and 2) availability of suitable hydrogen transport containers. The regulations are reported here, while the availability and applicability of hydrogen transport containers is reported in Deliverable 2.4.

The study of local regulations includes maximum length and weight of the trucks. In addition, also allowable vehicle height, width, and vehicle configurations, as well as safety regulations and other country-specific framework conditions, are accounted for.

In Sweden and Norway, different road classes apply. For Sweden these are reported for two road classes, while for Norway only roads with the 19.5 m classification are considered in the analysis.

¹ <https://www.fch.europa.eu/publications/study-fuel-cells-hydrogen-trucks>

Background

In Nordic countries the weight and length limits for the trucks are different from other European countries. Generally, in Europe maximum height is 4 metres and maximum length for lorry/trailer, road train, and articulated vehicle is seen in *Table 1*. The maximum weight is between 40-44 tonnes, which is not far from maximum weight of semi-trailer in USA in interstate roads (80,000 pounds, or about 36 tonnes).

However, in the Nordic countries, and especially in Finland and Sweden, the weight and length limits allow much larger cargos compared to many other European countries, as seen in *Table 2* and in *Table 3*.

The data is mostly from database collected by The International Transport Forum². There are a number of exceptions mentioned for the weights and dimensions and these are taken into account in the analysis. In addition, some of the most important exceptions concerning hydrogen transport are also left in footnotes.

In country specific Chapters, national regulations are discussed more in detail and information is then used in Deliverable 2.4 to define the maximum capacity of the hydrogen transport in each country.

Table 1. Maximum dimensions of lorries that can operate all over EU (in metres) and in Nordic countries

Country	Height	Width	Length		
			Lorry or Trailer	Road Train	Articulated Vehicle
All EU	4	2.55	12	18.75	16.50
Denmark	4	2.55	12	18.75	16.50
Finland	4.40	2.60	18	34.50	23
Iceland	4.20	2.55	12	22	16.50
Norway ³	Not defined	2.55	12	19.50	17.50 ⁴
Sweden ⁵	Not defined	2.60	24	25.25	24

Table 2. Maximum weights of lorries that can operate in EU (in tonnes) and in Nordic countries

	Weight per non-drive axle	Weight per drive axle	Lorry 2 axles	Lorry 3 axles	Road Train 4 axles	Road Train 5 axles	Articulated Vehicle 5 axles
All EU	10	11.5	18	24	32	40	40
Denmark	10	11.5	18	24	38	44	44
Finland	10	11.5	18	28	36	44	44
Iceland	10	11.5	18	26	36	40	44
Norway	10	11.5	19	26	39	46-50	46-50
Sweden	10	11.5	18	25/28	38	40	44 ⁶

² <https://www.itf-oecd.org/weights-and-dimensions>

³ The Norwegian road network is divided into categories in terms of permitted weights and dimensions. The permitted weight listed here applied to roads with the 19.5 m classification. The permitted weights listed here apply to roads with the Bk 10/50 classification.

⁴ When carrying a 45 ft container in intermodal transport: 17.65 m, 18.60 m with side loaders.

⁵ Full details for Sweden can be found in: <https://www.transportstyrelsen.se/4ab670/globalassets/global/publikationer/vag/yrkestrafik/lasta-lagligt/tran045-lasta-lagligt-eng-low.pdf>

⁶ 40 ft long ISO containers: 44 t.

Table 3. Maximum weights of lorries (in tonnes) with 6 axles or more

	Road Train 6 axles	Articulated Vehicle 6 axles	Road Train 7 axles	Articulated Vehicle 7 axles	Road Train 8 axles	Articulated Vehicle 8 axles	Road Train 9 axles
Denmark	50	50	56	56			
Finland	56	56	60	60	64-68	64-68	69-76 ⁷
Norway	50	50	60 ⁸	60			
Sweden ⁹	-	-	64 / 66	-	64 / 66	-	64 / 74

In addition to the information provided in the above tables, it should be noticed that in Finland an articulated vehicle with 9 axles (semi-trailer) can carry up to 71 tonnes if tractor has 4 axles and trailer 5 axles.

In Finland and Sweden, the maximum length of articulated vehicle are exceptionally long; 23 m and 24 m, respectively.

⁷ Not for ADR.

⁸ Timber transport between 19.5 m and 24 m with an overall wheelbase of at least 19 m: 60 t.

⁹ In Sweden, the maximum weight is based on the road class (BK1, BK2, BK3, BK4). On some roads (BK4), the permissible maximum weight is 74 t. The permissible maximum weight of a vehicle is determined by the distance between the outermost axle of the vehicle or combined vehicle. Therefore, in some cases the exact maximum weight is difficult to give.



Photo: Kelly Lacy, Pexels

Denmark

Possible vehicle configurations with national limits for heavy trucks

In Denmark, there is a multitude of possible vehicle configurations for heavy trucks, ranging from 3 to 7 axles. An overview is presented below. This list is not exhaustive but does entail the most common configurations.

As shown in *Table 1*, the maximum length of the articulated vehicle in Denmark is 16.5 m, while maximum length for the road train is 18.75 m. These dimensions allow single 40 ft container in articulated vehicle. The possible options with 4, 5, 6, and 7 axles are shown in *Figure 1*.

4 akslede vogntog / "trækker-trailer"

Tilladt totalvægt: **36.000 kg**

5 akslede vogntog / "trækker-trailer"

Tilladt totalvægt: **44.000 kg**

*) Hvis nogen af sættevognens indbyrdes akselafstande er mindre end 1,1 m, skal afstanden mellem bilens bageste og sættevognens forreste aksel være min. 3 m.

6 akslede vogntog / "trækker-trailer"

Tilladt totalvægt: **50.000 kg**

7 akslede vogntog / "trækker-trailer"

Tilladt totalvægt: **56.000 kg**

*) 54.000 kg hvis afstanden mellem bilens bageste og sættevognens aksler er mellem 3 og 4 m.

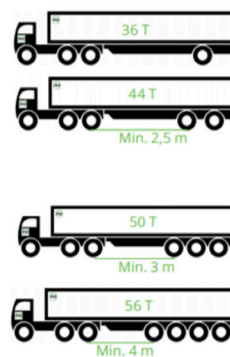


Figure 1. The possible trailer configurations in Denmark¹⁰.

¹⁰ Source: ITD, Total – og vogntogsvægte i Danmark, 2018.



Photo: Lex Valishvili, Unsplash



Photo: Olga Dudareva, Unsplash

Finland

Possible vehicle configurations with national limits for heavy trucks

In Finland the limits for truck dimensions and weight are largest in Europe¹¹, as shown in *Table 1*, *Table 2*, and *Table 3*. From January 2019, the maximum length is 34.5 metres, and the maximum weight has been 76 tonnes since 2013.

The maximum height is 4.4 metres, which allows transport of high cube containers (2.9 m). The possible vehicle configurations in regular traffic are shown in *Figure 2*.

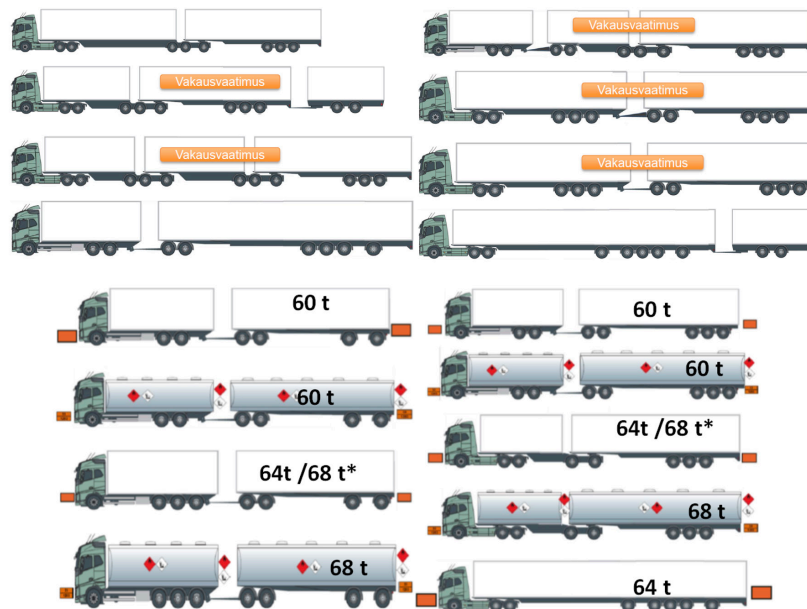


Figure 2. Above: Different vehicle combinations allowed in Finland. Below: Different ADR vehicle combinations allowed in Finland¹².

¹¹ Law: https://www.finlex.fi/fi/laki/ajantasa/2018/20180729_117_5 and Appendix 6.3

¹² From presentation of Petri Murto: https://www.skalfi/sites/default/files/sisaltosivujen_tiedostot/murto_adr_seminaari_2018.pdf

For ADR transport, however, the current weight limit is between 60 tonnes and 68 tonnes, limiting the possible transport options as shown in *Figure 2*¹³. It should be noticed that 8 axles are needed for 64 tonnes and 68 tonnes vehicles, while only 7 axles are needed for 60 tonnes vehicles in some cases. It should be added that 68 tonnes is possible with 9-axle articulated vehicle, when tractor has 4 axles.

A-double and B-link configurations

A-double configuration is a combination of truck and two-semi-trailers connected by an extra component, the dolly¹⁴. The configuration is illustrated in *Figure 3* (without a tractor). The two semi-trailers can be used individually. In *Figure 3* non-ADR vehicle is illustrated and therefore there are 9 axles, as maximum weight is 76 tonnes. As shown in *Figure 2* there are 7 axles for 60 tonnes ADR vehicle with A-double configuration.

The B-link (B-train) in *Figure 4* is a coupling device, which adds stability compare to A-double configuration. Therefore, the maximum weight in ADR transport is 68 tonnes, while for A-double it is only 60 tonnes.



Figure 3. A-double 2x13.6 trailers in Finland¹⁵.

¹³ https://www.finlex.fi/fi/laki/ajantasa/2018/20180729_124_5.

¹⁴ <https://www.bigtruckguide.com/get-your-a-b-cs-straight/>.

¹⁵ Different EMS2 trucks in Finland Otto Lahti 21.1.2020.

<https://www.traficom.fi/sites/default/files/media/file/Different%20EMS2%20Trucks%20in%20Finland.pdf>.



Figure 4. B-link (B-train) with 2x40 ft containers in Finland¹⁶.

¹⁶ Different EMS2 trucks in Finland Otto Lahti 21.01.2020



Photo: Sebastian_sch, Unsplash

Iceland

Possible vehicle configurations with national limits for heavy trucks

In Iceland, the maximum length of articulated vehicle is 18.75 m, while the maximum length of road train is 22 m, with (exemptions up to 25.25 m). The maximum weight for articulated vehicle is 44 tonnes and the maximum number of axles is 5. The height limit (4.2 m) in Iceland is more than typical limit in Europe (4 m) but less than the limit in e.g., Finland (4.4 m) and does not allow use of high cube containers.

This means that a single 45 feet gas container, with maximum weight of about 30 tonnes could be transported. The vehicle configuration would be close (similar) to 5 axles truck-trailer for Denmark, as illustrated in *Figure 1*.



Figure 5. An illustration of 5 axles truck-trailer with a maximum total weight of 44 tonnes¹⁷.

¹⁷ From presentation of Petri Murto:
https://www.skaf.fi/sites/default/files/sisaltosivujen_tiedostot/murto_adr_seminaari_2018.pdf



Photo: Josh Sorenson, Pexels

Norway

Possible vehicle configurations with national limits for heavy trucks

The maximum weight and dimensions for vehicles in Norway transporting hydrogen are defined by *Forskrift om bruk av kjøretøy* (Lovdata, 1990). As found from *Table 1*, the maximum width (2.55 m) is similar in Norway and Denmark, but slightly lower than the maximum width allowed in Sweden and Finland (2.60 m). As discussed in *Table 1*, the Norwegian road network is divided into categories in terms of permitted weights and dimensions. The analysis here applied to roads with the 19.5 m classification.

When it comes to the maximum vehicle weight (50 tonnes) and lengths (lorry: 12 m; articulated vehicle: 17.50 m; road train: 19.50 m), the figures are much lower in Norway than in neighbouring countries.

As a result, the optimal hydrogen transport configuration in Sweden and Finland will not be allowed operating on Norwegian roads and – consequently – hydrogen road transport solutions optimised for Norway will not be the preferred/most cost-efficient solution in Sweden and Finland. In fact, while modular road trains can carry hydrogen in Finland and Sweden, only vehicle configurations with a single towed module are allowed for hydrogen transport in Norway¹⁸. For 6-axis version, see *Figure 6*.

¹⁸ According to ADR 8.1.1., a transport unit loaded with dangerous goods may in no case include more than one trailer (or semi-trailer). Despite Norway has signed the multilateral agreement ADR 1.5.1, hydrogen transport units cannot be part of a vehicle configuration carrying more than a single trailer (or semi-trailer) or even extra-large single trailer (or semi-trailer) vehicle configurations.



Figure 6. 6-axis articulated vehicle (max. 17.5 m), modified from¹⁹.

In Norway, the maximum length of a vehicle transporting dangerous good²⁰ – including hydrogen – is 17.5 m. Now, the maximum length from the king pin to the very back of the trailer is 12 m and the maximum radii requirement in front of the king pin to tangent point is 2.04 m. For a regular rectangular (flat front) container, this means only 1.6 m of the container can be situated in front of the king pin. Adding the 12 m container that can be situated behind the king pin, the maximum allowed (flat front) container size transporting hydrogen in Norway is 13.6 m – or some 12 cm less than a regular 45 ft container (a 45 ft container is 13.716 m long).

Consequently, a regular 45 ft container is not allowed for hydrogen transport in Norway.

¹⁹ From presentation of Petri Murto:

https://www.skaf.fi/sites/default/files/sisaltosivujen_tiedostot/murto_adr_seminaari_2018.pdf

²⁰ According to Forskrift 1. april 2009 nr. 384 om landtransport av farlig gods med veiledning, § 18a. Bruk av ekstra store kjøretøykombinasjoner: Vehicles transporting dangerous goods requesting ADR-approval according to Part 9 as a FL, AT, EX/II or EX/III-vehicle can not be part of a modular road train or other road trains exceeding the weight and dimension limitations given in Forskrift 25. januar 1990 nr. 92 om bruk av kjøretøy § 5-4. In § 5-4, «normal» road trains are treated – those with a maximum total weight of 50 tonnes and a maximum overall vehicle length (semi-trailer or battery vehicle) of 17.5 meter. The «special» road train combinations including the 45 ft container configuration are treated in § 5-5, and thus not allowed for hydrogen transport according to Forskrift 1. april 2009 nr. 384 om landtransport av farlig gods, § 18a



Photo: Roberto Hanas, Unsplash

Sweden

In Sweden, the standard maximum weight for a loaded truck is 64 tonnes. Those trucks are allowed to drive on all BK1 roads, which covers about 95% of all public roads, Figure 7. However, the process of reclassifying the road network to BK4, meaning an increased vehicle weight to maximum 74 tonnes is well under way and around 20% of the public roads was to allow this by the end of 2019^{21,22}. Maximum height of a vehicle in Sweden is 4.5 meters for the main roads²³. This allows the transport of high cube containers.

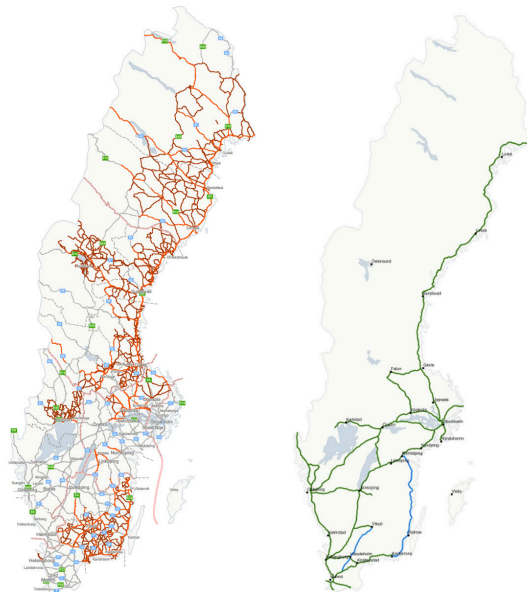


Figure 7. Left: BK4 roads in light red, BK4 with special terms in dark red²⁴. Right: Green showing roads that could be used for 34.5 m vehicles without modification and blue roads in need of modification²⁵.

²¹ <https://www.trafikverket.se/for-dig-i-branschen/vag/bk--barighetsklasser-pa-vagar-och-broar/>

²² <https://www.trafikverket.se/for-dig-i-branschen/vag/bk--barighetsklasser-pa-vagar-och-broar/barighetsklass-bk4/>

²³ <https://transportstyrelsen.se/sv/vagtrafik/Vagmarken/Forbudsmarken/Begransad-fordonshojd/>

²⁴ <https://www.trafikverket.se/globalassets/bilder-gemensamma/bk4-kartor/sverigekarta-bk4/bk4-vagar-sverigekarta.pdf>

²⁵ https://www.trafikverket.se/contentassets/1160ae4fe6504bba8e3629eee4b60d7c/langre-lastbilar_pa_det_svenska_vagnatet_for_mer_hallbara_transporter.pdf

Possible vehicle configurations with national limits for heavy trucks

Vehicle length is limited to 24 meters within the national system, with no further requirements for configuration and equipment. However, 25.25 m vehicles are allowed if they adhere to the regulations in the EU modular system with regards to ABS brakes, turning radius etc.²⁶. The maximum length for vehicles in Sweden is shown in *Figure 8*.

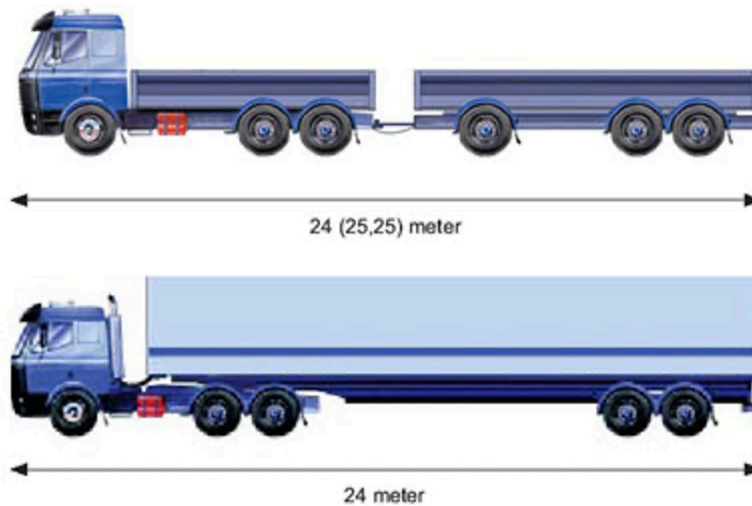


Figure 8. Maximum length for vehicles in Sweden in 2020²⁷.

The weight situation in Sweden is quite similar compared to Finland. While 9 axles are needed for the maximum ADR transport of 74 tonnes in Sweden, only 8 axles are needed for 68 tonnes ADR transport in Finland - clearly leaving the maximum payload difference less than 6 tonnes.

²⁶ <https://www.transportstyrelsen.se/sv/vagtrafik/Yrkestrafik/Gods-och-buss/Matt-och-vikt/Modulsystem/>

²⁷ <https://www.transportstyrelsen.se/sv/vagtrafik/Yrkestrafik/Gods-och-buss/Matt-och-vikt/Dimensioner/>

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