

Nikola electric-powered tractor-trailers

Peter Lobner, 2 April 2020

Introduction

Nikola Motor Company (<https://niklamotor.com/one>), which is based in Phoenix, AZ, is developing three electric-powered Class 8 heavy-duty tractors: the Nikola One and Nikola Two primarily for the North American market, and the Nikola Tre intended primarily for European and international markets. Nikola One will be available with a hydrogen fuel cell + battery electric powertrain. Nikola Two and Nikola Tre will be available with either a hydrogen fuel cell + battery powertrain or an all-battery-electric powertrain.



L to R: Nikola Two, Tre and One.

Source: Nikola Motor Co. via Cision PR Newswire

The company stopped taking pre-orders for its hydrogen fuel cell trucks after hitting 14,000. Nikola has partnered with Ryder System, Inc. to offer world-class sales, service and warranty through their 800 locations across North America.

Nikola is partnering with the Norwegian hydrogen fueling expert firm Nel ASA to deploy the hydrogen fueling infrastructure needed by Nikola trucks. This infrastructure will be deployed first along corridors used by key fleets that have placed pre-orders for Nikola tractors.

Nikola plans to lease trucks on a per mile basis that includes the cost of the truck, fuel and maintenance.

At the Nikola One unveiling in December 2016, Nikola announced that its first 5,000 trucks would be manufactured by Fitzgerald Glider Kits (<https://www.fitzgeraldgliderkits.com>) (a “glider kit” is a new truck without an engine or transmission). In parallel, Nikola will develop its own manufacturing plant in Pinal County, AZ at the Inland Port Arizona in Coolidge, which is expected to begin operation in 2024.

Standard Nikola trucks are equipped to support Level 4 and Level 5 vehicle autonomy. However, implementing autonomous vehicle operations will be left to third parties. For more information on Level 4 and 5, see the following Forbes article:

<https://www.forbes.com/sites/lanceeliot/2019/12/20/explaining-level-4-and-level-5-of-self-driving-cars-in-plain-english/#3c3733954709>

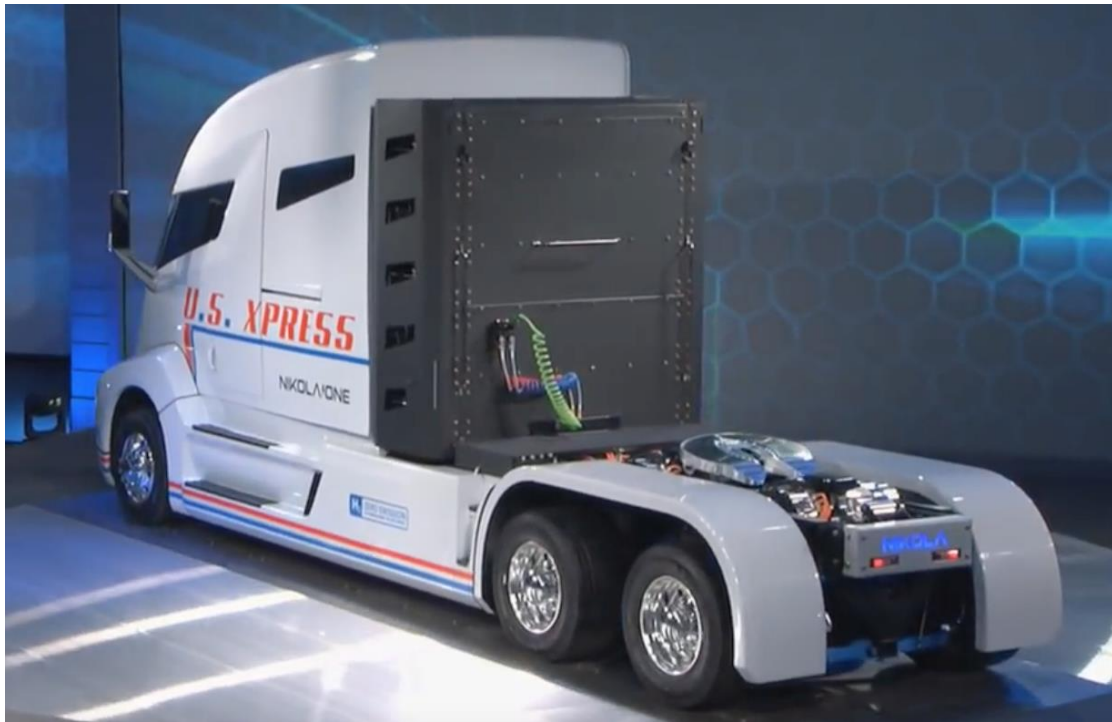
On 3 March 2020, Nikola Motor Company announced that it is going public by merging with VectoIQ Acquisition Corp., a publicly traded special purpose acquisition company.

Nikola One

The Nikola One hydrogen fuel cell + battery electric Class 8 tractor was unveiled on 1 December 2016.



Nikola One tractor at its unveiling Source: Nikola Motor Co.

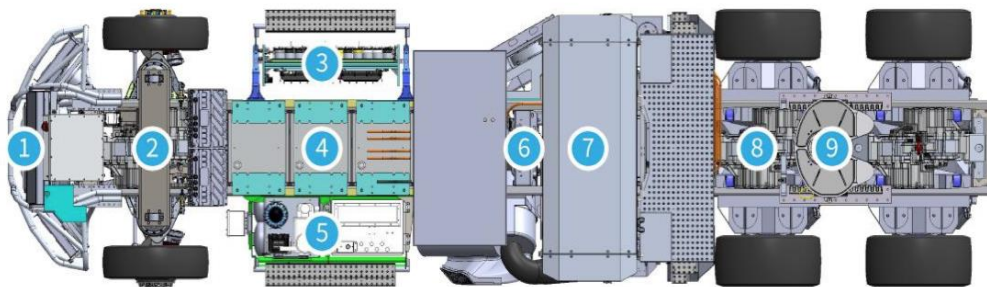


Nikola One tractor at its unveiling Source: Nikola Motor Co.

Basic features of this electric-powered tractor include the following:

- Zero emissions
- Advanced battery: 320kWh battery system
 - In Nov 2019, Forbes.com reported Nikola's claim that their new battery has double the energy density, only 40% of the weight and half the cost of 2170 lithium-ion cells, which are used in Tesla and other consumer-market electric vehicles. The new battery has a record power density 500 watt-hours per kg on the production cell level.
 - Nikola claims this battery performance was achieved by eliminating costly metals (nickel, cobalt and magnesium), use of a "free-standing electrode" and a "whole different type of chemical, with a lithium component."
 - Nikola claims that the new battery cell technology is environmentally friendly and easy to recycle.
- Hydrogen fuel cell: rated power of 300 kW
 - Provides energy to charge the battery underway.
 - Unspecified amount of compressed hydrogen fuel is stored in onboard tanks at 10,000 psi (70 megapascals).

- In Nikola Two, 80 kg of hydrogen yields about 3,000 kWh, which equals 3 MWh (megawatt-hours).
- All-electric drivetrain with four independent 800 volt electric drive motors, one on each tractor drive wheel.
- “Drive-by-wire” torque vectoring controls each tractor drive wheel independently for better maneuverability and stability.
- Regenerative braking and air-operated disc brakes
- Lower center of gravity than any other semi truck on the market (batteries, electric motors and the fuel cell are installed between the tractor’s frame rails).
- Range: 500 - 750 miles (807 – 1,207 km)
- Electric powertrain will deliver up to 1,000 horsepower and 2,000 pound-feet of torque
- Maximum gross vehicle weight (GVW): 80,000 lb (36,287 kg)
- Acceleration: 0 - 60 mph in 30 seconds at max. GVW
- Mid-cab entry makes it easier to get in and out.
- Digital cockpit with panoramic windshield for better visibility.
- Sophisticated information center includes route optimization.
- Surround vision cameras provide better situational awareness for normal maneuvering and collision avoidance.



Nikola One Drivetrain Arrangement (Source: nikolamotor.com)

- ① front radiator assembly; ② front motor gearbox; ③ power electronics; ④ battery storage system;
 ⑤ chiller and air tanks; ⑥ fuel cell; ⑦ hydrogen fuel system; ⑧ rear motor gearbox; ⑨ 5th wheel

*Top view of the Nikola One tractor with the exterior shell removed, showing the locations of key drive train components.
 Source: Nikola Motor Co. via UC Davis 2017.*



Nikola One with semi-trailer. Source: Nikola Motor Company



Nikola One. Source: Nikola Motor Company



Nikola One digital dash. Source: Nikola Motor Company

You'll find more information on the Nikola Motor Company and the Nikola One here:

- "Nikola One," on the Nikola Motor Co. website, here:
<https://nikolamotor.com/one>
- "Welcome to the Future," on the US Express website:
<https://www.usxjobs.com/nikola-2020/>
- John O'Dell, "Inside Nikola's Truck Technology – From Fuel Cells to Tail Lights," Trucks.com, May 2019:
<https://www.trucks.com/2019/05/22/inside-nikolas-truck-technology-fuel-cells-tail-lights/>
- "Nikola Receives \$1.7 Million Research Grant From DOE," Transportation Topics, 26 August 2019:
<https://www.ttnews.com/articles/nikola-receives-17m-research-grant-doe>
- Alan Ohnsman, "Nikola Motor's Bombshell Battery Claim Irks Experts, Who Think Its Secret May Lie In Sulfur," Forbes.com, 24 November 2019:

<https://www.forbes.com/sites/alanohnsman/2019/11/24/nikola-motors-bombshell-battery-claim-irks-experts-who-think-its-secret-may-lie-in-sulfur/#53501e3c7d89>

- “Nikola Going Public, Expects U.S. Electric Truck Production to Start Next Year,” HDT Truckinginfo, 3 March 2020: <https://www.truckinginfo.com/352314/nikola-going-public-expects-u-s-electric-truck-production-to-start-next-year>
- A. Burke & H. Zhao, “Fuel Cells and Hydrogen in Long-Haul Trucks,” University of California (UC) Davis, May 2017: <https://steps.ucdavis.edu/wp-content/uploads/2017/05/Andy-Burke-Hydrogen-Fuel-Cell-Trucks.pdf>

The following videos provide additional views and more information on the Nikola One:

- “Nikola Motor Company - Nikola One Semi Electric Truck Unveiling - Official Video “ (42:05 minutes), Nikola, 1 December 2016: <https://www.youtube.com/watch?v=wLidTCqAAAtY>
- “Nikola Motor Company - Nikola One Electric Semi Truck in Motion” (0:39 minutes), Nikola Motor Company, 25 January 2018: <https://www.youtube.com/watch?v=IAToxJ9CGb8>
- “Meet Nikola Motor - The Company That Wants To Kill Diesel Trucks” (14:28 minutes), Ecotricity NZ, 29 April 2019: https://www.youtube.com/watch?v=0T_a0ffmYZs

Nikola Two

The Nikola Two electric day cab Class 8 tractor is a zero emissions electric vehicle developed for the North American regional freight market. The Nikola Two was officially unveiled on 16 April 2019 at Nikola World 2019 in Scottsdale, AZ. It will be available in two powertrain configurations: a hydrogen fuel cell + battery electric powertrain or an all-battery electric powertrain.



Nikola Two tractor. Source: Nikola Motor Co.

Basic features of the Nikola Two electric-powered truck include the following:

- Energy storage:
 - Hydrogen: 80 kg of hydrogen storage, with an energy content of about 3 MWh (megawatt-hours)
 - Batteries: 800 volts; 500, 750 or 1,000 kWh options
- 500 or 1,000 horsepower (372 kW or 735 kW) (one or two powered axel configurations)
- Torque: 2,000 lb-ft
- Range: 500 to 750 miles (807 – 1,207 km)



*Nikola Two prototypes demonstrated at Nikola World.
Source, both photos: screenshots from Commercial Carrier Journal
video.*

Fully-functioning Nikola Two prototypes have been operating since 2019. In March 2020, Nikola announced that it planned to start of production of Nikola Two fuel cell electric vehicle in 2023.

More information on the Nikola Two is here:

- “Nikola Two,” on the Nikola Motor Co. website:
<https://nikolamotor.com/two>

Videos:

- “Nikola Two Hydrogen Electric Truck Unveiling” (12:08 minutes), Nikola Motor Co., 18 April 2019:
<https://www.youtube.com/watch?v=-R7F6HFQXz8>
- “Nikola Two demo” (2:04 minutes), Commercial Carrier Journal, 17 April 2019:
https://www.youtube.com/watch?v=h30TNwfq_Ss
- “Nikola Wants To Revolutionize The Trucking World With These H2 Electric/Battery Electric Trucks” (14:22 minutes), Transport Evolved, 29 April 2019:
<https://www.youtube.com/watch?v=BVEnvcrS114>
- “Nikola World Recap: 5 new vehicles in 2 days” (16:42 minutes, Tesla Two starts at 4:18), Sean Mitchell, 18 April 2019: <https://www.youtube.com/watch?v=5zHPf8mlmoo>
- “2020 Nikola Two Fully Electric and Hydrogen Fuel Cell Electric Day Cab Semi-Truck” (5:07 minutes), InterUnet Automotive, 8 November 2019:
<https://www.youtube.com/watch?v=PElf27fs16Q>

Nikola Tre

Nikola launched the third model of their zero emission Class 8 electric tractors on 5 November 2018. The heavy-duty Tre, designed primarily for the European and international markets, is based on truck maker Iveco’s (<https://www.iveco.com/germany/Pages/Home-page.aspx>) S-WAY heavy freight vehicle and meets the current EU size and length restrictions for heavy trucks. The Tre will be available with the same two electric drivetrain options as the Nikola Two, with the similar battery size options, and a smaller, 60 kg hydrogen storage capacity, which would have an energy content of about 2.25 MWh (megawatt-hours).



Nikola Tre tractor. Source: Nikola Motor Co.



The current diesel-powered Iveco S-Way. Source: Iveco.

In February 2020, Nikola Motor Corp. and joint venture partners Iveco and FPT Industrial announced they will manufacture the battery-

electric version of the Nikola Tre at Iveco's plant in Ulm, Germany, beginning in 2021. The first models will be articulated trucks with modular, scalable batteries. The electric powertrain will be able to deliver up to 480 kW (644 horsepower) of continuous power output. Nikola announced that North American production of the Tre battery-electric vehicle is scheduled to begin in their new facility in Coolidge, Arizona, in 2022.

The battery-electric model of the Tre is the first step toward the company producing a hydrogen fuel-cell electric model.



*Concept drawing of a Nikola Tre tractor on the road.
Source: Nikola Motor Company*

More information on the Nikola Tre is here:

- “Nikola Tre,” on the Nikola Motor Co. website:
<https://nikolamotor.com/tre>
- “Nikola Launches Stunning Truck for the European Market,”
Nikola Motors, 5 November 2018:
https://nikolamotor.com/press_releases/nikola-launches-stunning-truck-for-european-market-53

- “Nikola to Build Tre Electric Truck for Europe in Germany,” HDT Truckinginfo, 6 February 2020:
<https://www.truckinginfo.com/350612/nikola-announces-tre-electric-truck-production-joint-venture-for-europe>

Nikola’s planned hydrogen infrastructure

In November 2018, Nikola Motor Company reported:

“By 2028, Nikola is planning on having more than 700 hydrogen stations across the USA and Canada. Each station is capable of 2,000 to 8,000 kgs of daily hydrogen production. Nikola’s European stations are planned to come online around 2022 and are projected to cover most of the European market by 2030.”

The stations will be sized to deliver about 8 tons (7.25 metric tons) of pressurized hydrogen per day, enough to refuel about 150 trucks per day. Hydrogen filling is accomplished at 10,000 psi (70 megapascals, 700 bar). Refueling with hydrogen is expected to take 10 – 15 minutes.

Nikola has chosen the Norwegian hydrogen fueling expert firm Nel ASA (<https://nelhydrogen.com>) as their sole equipment supplier to create the worldwide hydrogen fueling network for Nikola fuel cell vehicles.

Nel’s process for producing and dispensing hydrogen is shown in the following flow chart. The hydrogen fueling stations will include on-site renewable electric power generation to meet part (30 – 40%) of their electric power needs, with the balance being purchased.



Helium production process. Source: Nikola Motor Company



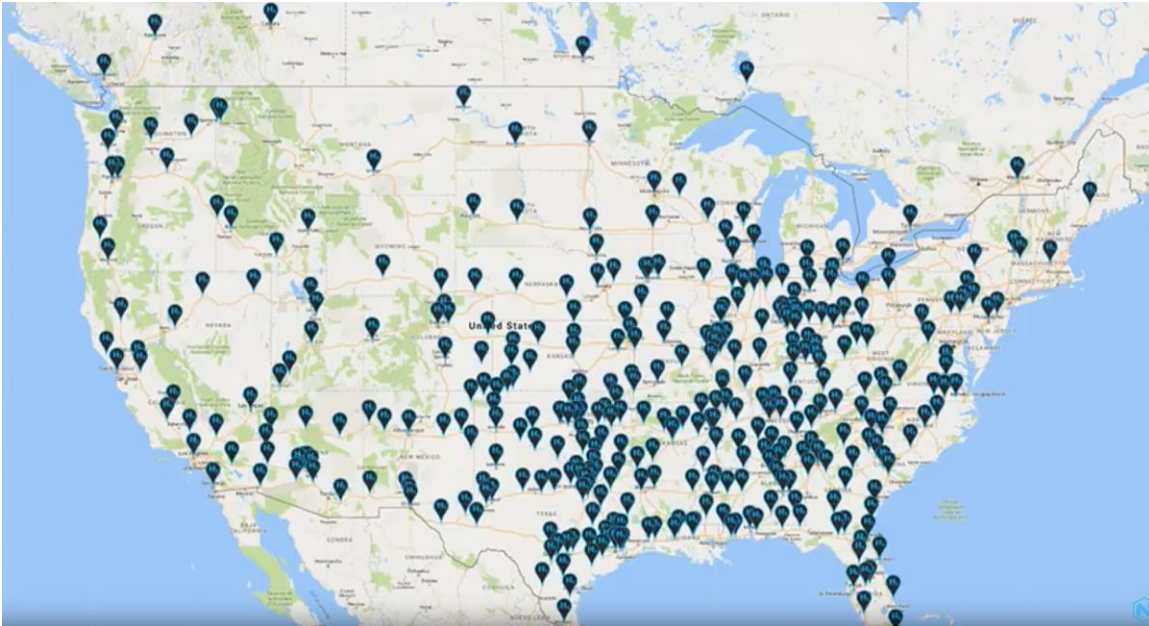
Nikola / Nel concept drawing for a hydrogen fueling station with onsite solar power generation, hydrogen production by electrolysis, and several bays for dispensing pressurized hydrogen.

Source: Nikola Motor Company



Nikola / Nel concept drawing for a hydrogen dispensing bay at a hydrogen fueling station. Source: Nikola Motor Company

Nikola's plans for the North American hydrogen fueling network are shown in the following map.



Planned N. Am. Hydrogen fueling network. Source: Nikola Motor Co.

For more information on Nikola's planned hydrogen infrastructure, see the following:

- "Hydrogen Advantages," on the Nikola Motor Co. website here: <https://nikolamotor.com/hydrogen#hydrogen-advantages>
- "Hydrogen Fueling Equipment," on the Nel ASA website: (<https://nelhydrogen.com/hydrogen-fueling-equipment/>)