



KEY TECHNOLOGY NEEDS FOR 70 MPA HEAVY-DUTY SEMI STATIONS



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EVP, TECHNOLOGY, H2 & FC

PRESENTATION OVERVIEW

- **NIKOLA OVERVIEW**
- **HD HYDROGEN INFRASTRUCTURE**
- **70MPA HD FUELING:**
 - **JUSTIFICATION**
 - **DEVELOPMENT, VALIDATION TO STANDARDIZATION NEEDS**
 - **NEED FOR A CERTIFICATION CONSORTIUM**





NIKOLA TWO™

- 100% ZERO TAILPIPE EMISSIONS
- 100% ELECTRIC DRIVE
- HYDROGEN POWERED
- 750 km - 1,200 km RANGE
- AUTONOMOUS CAPABILITIES
- 2,000 FT. LBS TORQUE
- 1,000 HORSEPOWER
- 125kW-250 kWh BATTERY
- 240 kW FUEL CELL



NIKOLA HYDROGEN STANDARD STATIONS RETAIL FOR HD & LD

- Standard” Modular 4-8 Ton/day station for sale of retail hydrogen for Nikola and other customers
- Scalable up to 32 ton/day H2 (for truck Depot, etc.)
- SAE J2601 H70 Light Duty
 - Constrained to 60g/s
 - Constrained to J2799 IrDa
- Dispensers Unidirectional
- H70 HF Heavy Duty Dispensers
 - Goal: 180g/s + (TBC)
 - Time: 10 Minute, 80kg Fill
 - Bidirectional Communications



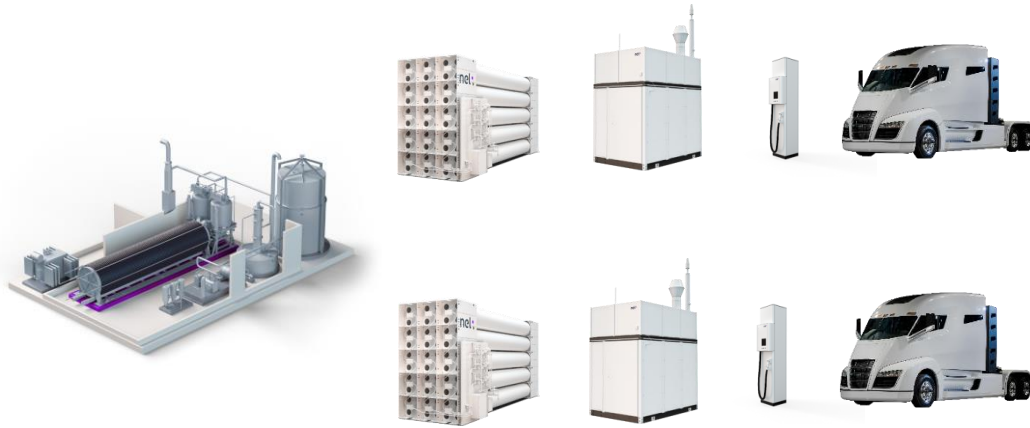
H2 FUELING FROM ELECTROLYSIS

HYDROGEN GENERATION
WITH RENEWABLES + GRID
WITH LOW COST ELECTRICITY



Development Stations 2019

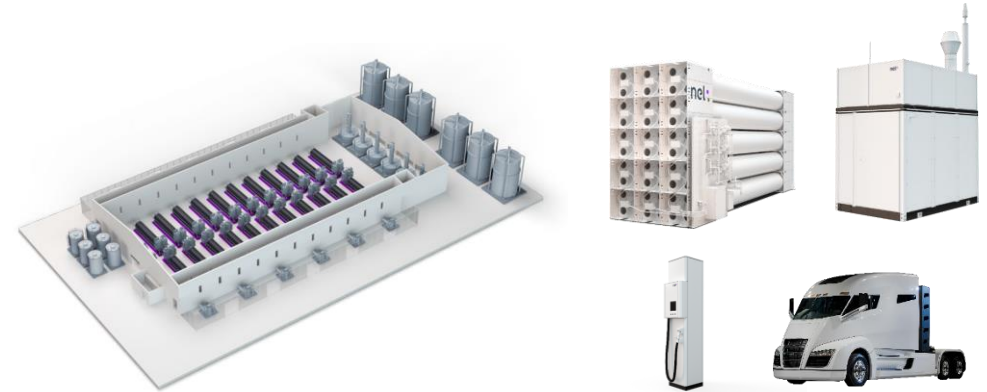
1,000kg hydrogen per day



Dual fueling lines

Commercial Stations → 2023+

8-32 tons hydrogen per day



NEL H2 STATIONS FOR NIKOLA:

- NEL ALKALINE ELECTROLYSIS “TRIED AND TRUE” TECHNOLOGY, HIGH EFFICIENCY (20 YEAR+ LIFETIME)
- NEL 70 MPA HYDROGEN FUELING FOR BOTH LIGHT DUTY AND HEAVY DUTY
- HYDROGEN FOR \$5-6 TO CONSUMER (ELECTRICITY @\$0.04/KW),

WHY 70MPa FOR 40 TON SEMIS?

SHORT REVIEW OF POSSIBLE TECHNOLOGIES FOR FAST FUELING & 1000KM+ RANGE-COMMERCIAL TRANSPORT



- 35MPa: Reliable, cheaper H₂ Technology, however not enough range (Roughly 1/2 70MPa)
- 50MPa: Reliable, cheaper H₂ Technology, however not enough range, not yet standardized (Roughly 3/4 70MPa)
- LH₂: Reliable, cheap, energy dense, range possible, however there are boil-off considerations (3%/day) and not enough liquefiers in World to supply in 5-10 years without massive investment
- LOHC: Liquid Organic HC: Cheaper, Energy Dense, unproven technology, not feasible for onboard vehicle use at this time.
- ✓ 70MPa HD: Reliable, Energy Dense (saves 500kg), enables range, however costlier, new fueling hardware and protocol needs to be developed for fast fueling: 80kg in 10 minutes.



70 MPA HD FUELING: DEVELOPMENT NEEDS



- 70 MPa Hydrogen Fueling protocol: 10+ minutes +NFPA Leak Checks (~12 min.),
- H2 Simulation + Fueling Lab Testing needs
- New HD H70 high flow nozzle, break-way and hose assembly
- Hydrogen Storage H70 Receptacle Check Valve
- SIL rated, Bi-direction communication
- New compressor for high flow to 80kg
- New station cooling capacity for T40 HF
- New High Capacity H2 Station Storage Vessels @50MPa (much greater than 40kg)

70 MPA HD –H2 INTERFACE- COMPONENTS VALIDATION/CERT.

Proposal for Validation/ information for certification to expedite HD Fueling timeline:

- H70 high flow nozzle, No-freeze on!
- Break-way (pull tests, etc.)- No leak!
- Hose (bending, burst tests, etc.)- Low Permeation!
- H70 Receptacle & Check Valves- No chatter!



CONCLUSION



- **HYDROGEN FUELING FOR HEAVY DUTY NEEDS TO BE 70MPA FOR NEAR AND MID-TERM TO MEET RANGE NEEDS**
- **THERE ARE NEEDS FOR NEW FUELING HARDWARE AND PROTOCOLS FOR 70MPA HD ON THE STATION/ VEHICLE**
- **COORDINATED DEVELOPMENT IS NEEDED IN ORDER TO FACILITY AN EXPEDITED TIMELINE**
- **STANDARDIZATION & CERTIFICATION LED FROM HD OEMS**
- **CONSORTIUM NEEDED FOR VALIDATION OF 70MPA FUELING COMPONENTS**
- **NEW TEAM FOR HD FC STANDARDS**