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Energy SPACs: Technology and Innovation Accelerate the Pace of Decarbonization

Decarbonization is a mega trend that will provide myriad benefits. Globally, government officials and industry professionals are grappling with the following question: how do we grow global economies, eliminate energy poverty, and reduce carbon emissions? Carbon emissions in the U.S. and Europe have declined due to increased solar and wind generation. But a goal of net zero carbon emissions by 2050 has emerged. Recently, the Executive Director of the International Energy Agency (IEA) Dr. Fatih Birol stated "almost half of the emissions reductions needed to reach net zero by 2050 will need to come from technologies that have not reached the market today." The economic prize for disrupting the current global energy sector is substantial with an estimated total addressable market of over $11 trillion[1]. Entrepreneurs like Bill Gates are turning to technology and innovation to reach net zero by 2050. The emergence of special purpose acquisition companies or SPACs (Figure 1) provides investors an opportunity to buy publicly-traded stocks of companies that are using technology and innovation to disrupt the global energy sector and accelerate the pace of decarbonization.

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> Dr. Fatih Birol Executive Director
> - International Energy Agency (February 3, 2021)

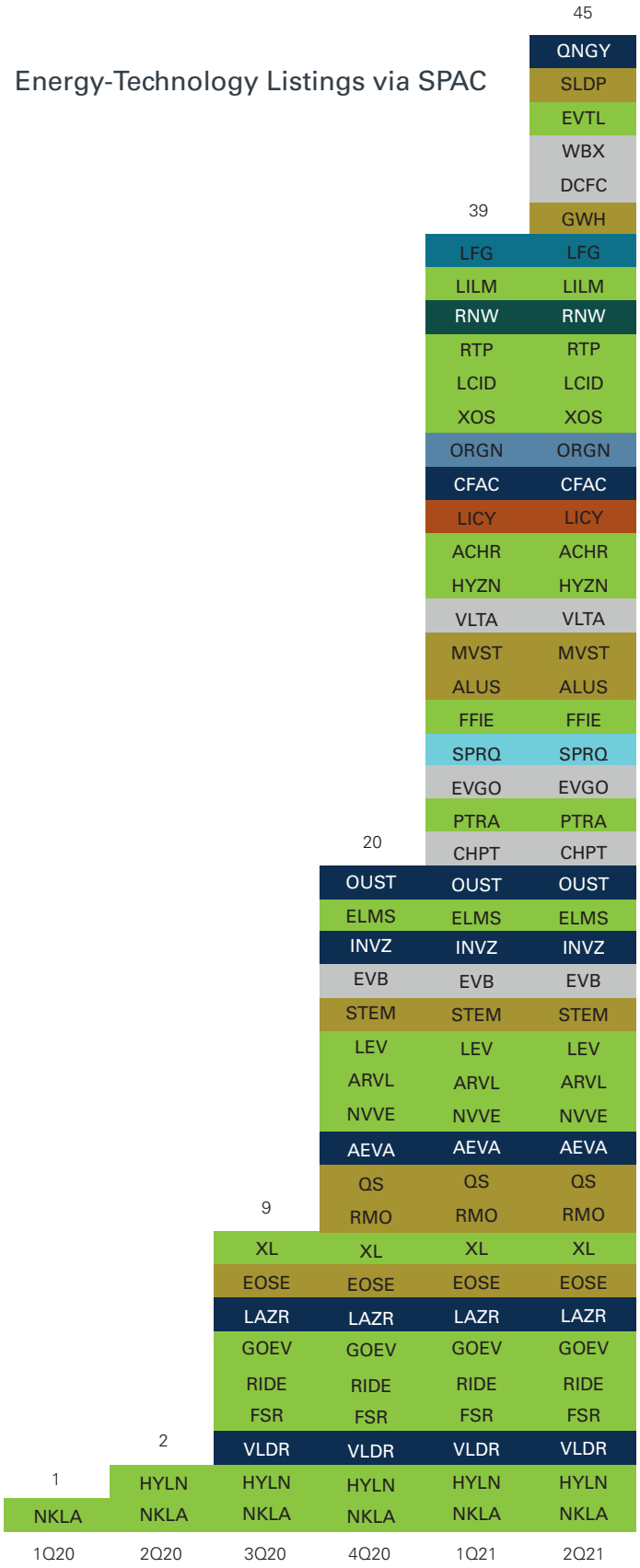

Figure 1: Growth in Energy-Technology SPACs[2]
Source: Company filings as of 6/30/2021

Energy-Technology SPACs

As the world was in the early stages of what would become a global pandemic, a hydrogen truck maker named after the inventor of the first alternating current (AC) motor became the first non-traditional, energy-technology publicly traded stock via SPAC. In March 2020, Nikola announced plans to merge with VectoIQ Acquisition Corporation, a blank check company or SPAC formed by investors with the purpose of raising money through an IPO to eventually acquire another company. Nikola's announcement unleashed a frenzy of SPAC IPOs that have merged with pure-play, energy-technology businesses offering numerous investment opportunities. Figure 1 illustrates the rapid rise in the number of energy-technology SPACs. Through June 30, 2021, 45 publicly listed energy-technology companies have gone public via a SPAC. In addition, there are more than 18 other current SPACs that are expected to merge with energy-technology companies. By the end of 2021, there could be 50-75 energy-technology publicly listed stocks via a SPAC. A complete list of SPACs and former SPACs is included in the SPAC Universe and SPAC Landscape sections at the end of the paper.

- Renewable Natural Gas
- Lithium-ion recycler
- Renewable Chem
- Battery Storage
- Charging Station
- Autonomous Vehicles Components
- Rooftop Solar
- Wind and Solar Generation
- EV Transportation

The aggregate market cap of the energy-technology SPACs is approximately $99 billion as of June 30, 2021. Figure 2 below illustrates the market cap allocated by pure-play energy- technology.

Electric vehicle (EV) transportation represents 47% of the market cap of the energy-technology companies. After solar and wind generation, EV transportation is the most commercially advanced energy technology that is decarbonizing the transportation sector today. Eighteen former SPACs make up this category including: EV passenger cars, pickup trucks, vans, delivery vehicles, semi-trucks, and even flying taxis.

Battery storage is the energy-technology with the highest potential to accelerate the pace of decarbonization. Battery storage companies are using software to optimize lithium-ion battery storage. Other companies are exploring different chemistries using zinc and solid-state to lengthen battery storage capability beyond a few hours. Eight battery storage former SPACs or SPACs with identified targets represent 19% of the total market cap.

Autonomous vehicles components represents 15% of the market cap of former SPACs. This includes seven companies that are advancing a technology that is key for autonomous vehicles called LIDAR, an acronym for light detection and ranging.

Charging stations make up 15% of the total market cap. Charging stations are critical infrastructure required for the expansion of electric vehicles. These companies are focused on U.S. and Europe expansion of electric charging networks.

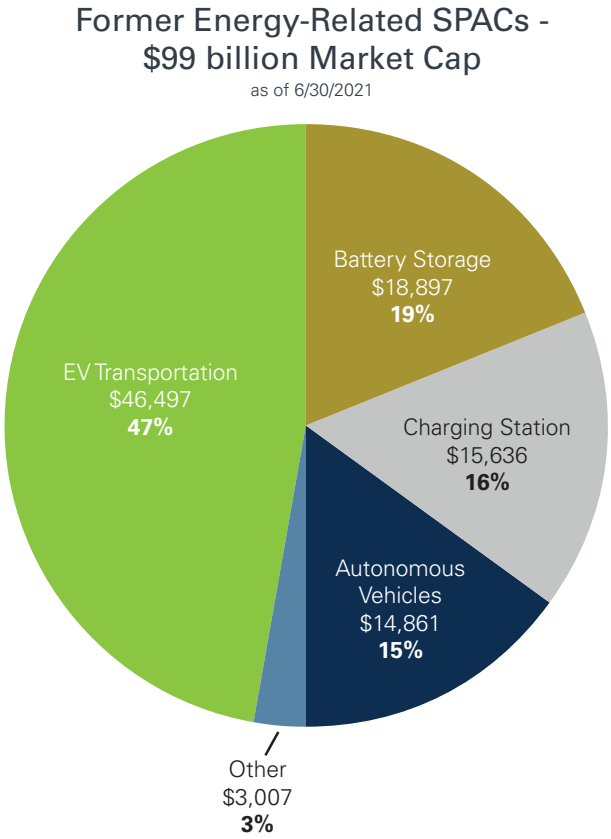

Figure 2 – Energy-Technology SPACs by Market Cap

Source: Company filings as of 6/30/2021

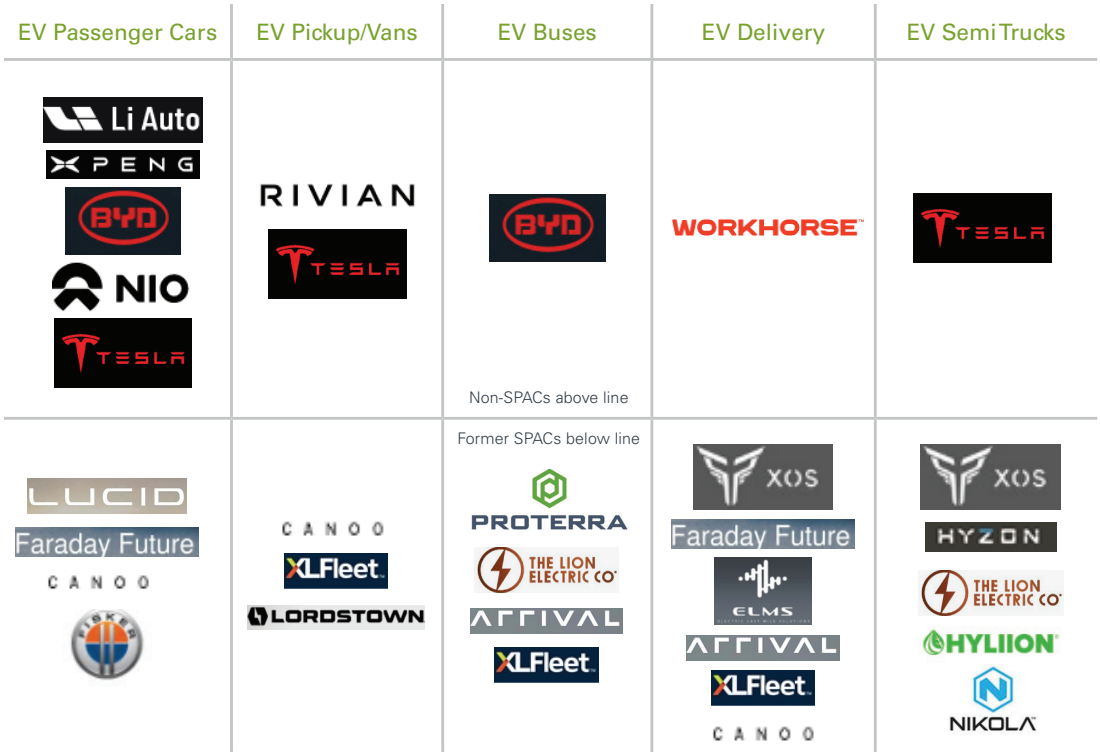

Figure 3 Electric Vehicle by Transportation Type

Source: Company filings as of 6/30/2021

Other energy technologies related former SPACs represent 3% of total market cap including a renewable natural gas provider, the largest wind and solar generation provider in India, a lithium-ion recycling company, a renewable chemical provider, and a financing provider for residential rooftop solar.

From here, each energy-technology will be explained in a little more detail. Each of the 45 companies in the SPAC Universe listed in Tables 5 and 6 will be highlighted with explanations on how the company is participating in the specific energy technology.

EV Transportation

EV pure-plays have emerged across all types of vehicle classifications providing a menu of investing options. EV transportation includes former SPACs and non-SPACs like Tesla. Most former SPACs are targeting a specific type of vehicle. Figure 3 above illustrates the various EV stocks by transportation type.

The transportation industry produces approximately 14% of the 50 gigatons of carbon emissions worldwide[3]. In Europe, countries such as the United Kingdom, the Netherlands, Sweden, Germany and France are phasing out the internal combustion engine or ICE vehicles over the next two decades. In the U.S., California passed regulations requiring half of trucks sold in the state to be zero emissions by 2035 and 100% by 2045. EV penetration rates are expected to increase as the cost of lithium-ion battery packs decline from $200 per kilowatt-hour (kwh) today to $94/kwh in 2024 and $52/kwh in 2030. EV could reach price parity with ICE vehicles in the U.S. and Europe between 2024 – 2026 and in China between 2028 – 2030[4].

EV Passenger Cars

The first all-electric car debuted in 1890 as an electrified wagon designed by William Morrison in Des Moines, IA. The wagon reached a top speed of 20 miles per hour using 24 battery cells that needed recharging every 50 miles[5]. However, the introduction and subsequent mass production of the gas-powered Model T starting in 1908 that cost $825 eliminated consumer demand for electric wagons. Fast forward 100 years to 2008 with Tesla releasing its first all-electric car – the Tesla Roadster. With a sticker price of $109,000, the Roadster accelerated from 0 to 60 miles per hour in 3.9 seconds and had a range of 244 miles on a charge.

Today, EV passenger cars represent approximately 1-2% of the global fleet. The global EV market is expected to grow at a 31% compound annual growth rate (CAGR) from 2020 through 2030. By 2030, EV passenger car sales are projected to account for almost 30% of global sales[6]. Tesla dominates the U.S. market delivering 180,667 battery electric vehicles (BEV) during the fourth quarter of 2020 representing 79%[7] of EV sales in 2020. In Europe, EV sales are more evenly distributed between Volkswagen, Renault, and Tesla. Lastly, in China, leading EV sales include: BYD, SAIC-GM-Wuling, and Tesla. Other than the cost, one of the biggest impediments to buying an EV for consumers has been battery anxiety or range anxiety that is the fear of running out of battery while driving an electric vehicle.

Several pure-play EV passenger car stocks have debuted as former SPACs. Table 1 compares the various former SPAC EV passenger car models to Tesla's current lineup. The former SPACs that are focused on the EV passenger car market including the following:

- Lucid (NYSE: CCIV) is a luxury car manufacturer forecasted to deliver 20,000 luxury sedans in 2022 with sales increasing at a 88% annual growth rate through 2026 including sales of sedans and luxury SUVs. The CEO is the former chief engineer of the Tesla Model S.
- Faraday Future (NYSE: PSAC) anticipates introducing three luxury EV models at different pricing points. The most expensive FF 91 series debuts in 2022, followed by FF81 series in 2023 and FF 71 series in 2025. Annual growth in unit sales is forecasted to be 401% through 2025.

Table 1 – EV Passenger Car Models

EV Passenger Car	Model	Base Price	Battery Range (in miles)	Horsepower (hp)
LUCID	Dream	$169,000	517	1080
	Grand Touring	$139,000	517	800
	Touring	$95,000	400	620
	Pure	$76,500	400	480
Faraday Future	FF 91	$100,000- $180,000	378	1050
	FF 81	$59,000- $95,000	N/A	N/A
	FF 71	$45,000-$65,000	N/A	N/A
	Fisker Ocean	$37,499	275	300
CANOO	Lifestyle	Subscription Model	250	300
TESLA	Model S	$69,420	450	1020
	Model 3	$36,990	300	480

Source: lucidmotors.com, ff.com, fiskerinc.com, canoo.com, tesla.com

- Fisker Inc. (NYSE: FSR) is introducing its first model, Fisker Ocean, in 2022 followed by a pickup and crossover electric vehicle in 2024 and 2025. Overall, unit sales growth are forecasted to grow by 200% annually from 2022 – 2025. Fisker's CEO is Henri Fisker who designed the EV model for BMW and is a board member of Aston Martin. Its sedan is priced to compete with Tesla Model 3.
- Canoo (NYSE: GOEV) is rolling out a new EV line including a passenger car, a pickup, a van, and a delivery vehicle. Canoo is implementing an innovative subscription model that is an alternative to buyng or leasing a car today. The model is similar to the one used by electric scooter companies Lime and Bird. Under the subscription model, a customer downloads the Canoo app and picks up their Canoo car at a nearby location. The subscription requires a minimum term of one month. The monthly payment incorporates all of the necessities of driving the car including: insurance, charging, registration and routine maintenance. Customers can drop off their Canoo car at the closest location at anytime. Canoo believes that a try before you buy concept will increase EV penetration rates.Canoo's passenger car will be available in 2025.

EV Pickups/Vans

The market for electric pickups and vans is the smallest of the EV transportation segment but remains untapped. In July 2021, Rivian, a private company, is expected to deliver the first electric pickup truck. The R1T truck will be priced at $75,000 with a 400-mile battery range and towing capacity of 11,000 pounds. Amazon has pre-purchased 100,000 delivery vans from Rivian as well.

Three former SPACs are participating in the EV pickup market as well including:

- Lordstown (NYSE: RIDE) is a pure-play electric pickup provider. Lordstown's Endurance full-size electric pickup is manufactured in Lordstown, OH and is priced at $52,500 with a 250 mile range and 7,500 pounds of towing capacity. Lordstown is expected to sell 2,200 pickups in 2021 with annual growth of 265% forecasted through 2024.
- Canoo (NYSE: GOEV) is offering a 7 passenger seat lifestyle vehicle similar to a van under its subscription model as discussed above. Unit sales are forecasted to begin in with 10,000 vans in 2022 growing to 50,000 units by 2024.
- XLFleet (NYSE: XL) provides electrified powertrains mostly to fleet vehicles using a business model is discussed in more detail in the EV Delivery discussion below. XL does not have its own brand of pickup or van. Instead, XL electric powertrains are available to be installed on the chassis of Ford, GMC, Chevrolet and Isuzu pickups.

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EV Buses

Electric buses have gained the most market share. It's estimated that there about 425,000 electric buses world-wide representing about 17% of the world bus fleet[8]. EV buses represented about 45% of the new global EV vehicle sales in 2020[9]. China operates the largest electric bus fleet and China-based BYD Company is the largest EV bus company in the world. However, the U.S. is expected to lead demand increases for the electric bus over the next several years. EV bus sales in North America are expected to be 50% total sales by 2025. Several states like California that have mandated all mass transit buses be zero-emission by 2029. Several pure-play EV bus companies have recently listed via SPACs including:

- Proterra (NYSE: ACTC) is a leading U.S. EV bus company with a first mover competitive advantage. Proterra's EV solution offers a battery system that results in lower costs and higher energy density. Also, Proterra sees vehicle-to-grid (V2G) revenue opportunities. V2G is also referred to as smart charging in that it charges and discharges electricity from an electric vehicle flexibly and economically. EV owners are able make money by selling power back to the grid or save costs by allowing buildings to use power from the EV's batteries during peak consumption. Proterra generates about $193 million in annual revenue and is expected to grow annually by 67% per year through 2025.
- Lion Electric Co (NYSE: LEV) is predominately an EV bus manufacturer with 98% of 2020 sales coming from sale of 108 EV buses. Lion's buses are purpose-built designed and include proprietary battery technology including V2G revenue opportunities well. Lion units sales are forecast to grow by 118% annually through 2024.
- Arrival (NYSE: ARVL) distinguishes its vehicles with customized solutions manufactured in microfactories that have lower production volume capacity requiring less capex and operating expense due to smaller size. Arrival is forecasted to manufacture 1,000 buses in 2022 growing to 11,300 by 2024.

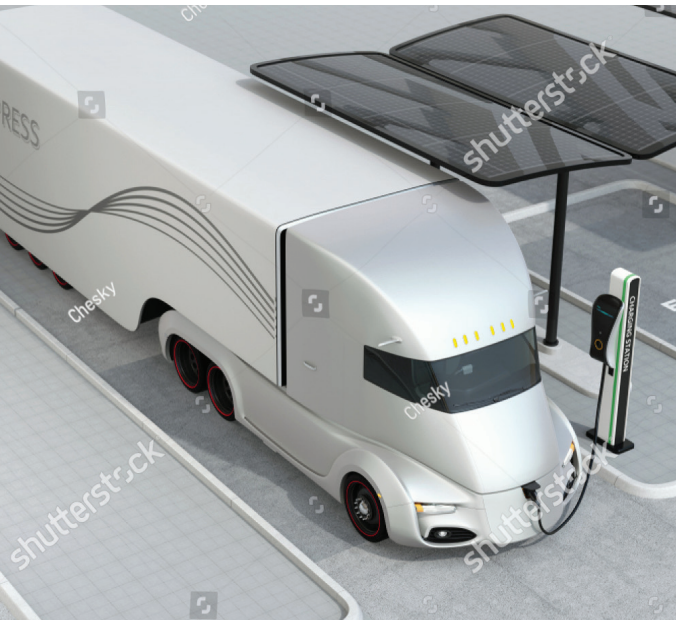
EV Delivery

Consumer shifts to online shopping and demands for immediate delivery are increasing the need for delivery vehicles that are the last mile delivery to the consumer. Between 2021–2025, demand for delivery vehicles is expected to increase by 11% annually. EV delivery vehicles are forecasted to gain market share as well. Several former SPACs are participating in the EV delivery vehicle market including the following:

Company	Driving Range (miles)	2021 Unit Sales	2024 Unit Sales	2025 Unit Sales	% of 2025 Sales
ARRIVAL	Up to 200	0	168,000	N/A	65%
XOS	Up to 250	116	13,878	18,521	55%
ELMS	Up to 150	4,000	55,000	83,000	100%
CANOO	Up to 200	0	10,000	20,000	21%
Faraday Future	Up to 330	0	8,000	35,000	11%

Source: Company filings as of 3/31/21

- Arrival (NYSE: ARVL) utilizes its microfactory concept to manufacture smaller, cheaper EV delivery vehicles. Arrival uses a composite material rather than steel for vehicle shell lowering cost of the vehicle. Arrival has a contracted order for 10,000 delivery vehicles with UPS with an option to purchase additional 10,000 delivery vehicles.
- XOS (NYSE: NGAC) differentiates itself through its customized battery designed for specific range of delivery vehicle minimizing battery price. In addition, modular battery design with specialized cooling system improves battery performance.
- Electric Last Mile Solutions (NYSE: FIII) is the cheapest electric delivery vehicle starting at $25,000 given weight of less than 6,000 pounds. Electric Last Mile Solutions is solely focused on the growing need for EV delivery vehicles.
- Canoo (NYSE: GOEV) is offering a multi-purpose electric delivery vehicle with 200+ miles of range with a starting price of $33,000. Delivery vehicles represent about 21% of Canoo's 2025 unit sales.
- Faraday (NYSE: PSAC) offers customers a purpose built smart last mile delivery vehicle with up to 330 mile of range. Unit sales are forecast to begin in 2023 rising to 35,000 unit sales in 2025.
- XL Fleet (NYSE: XL) – XL is a leading provider of fleet electrification for commercial vehicles in North America with over 3,700 electrified powertrain systems sold. Note that XL sells an electrified drive systems that is comprised of an electric motor that is mounted onto the vehicles drive shaft, an inverter motor controller, and a lithium-ion battery pack to store energy. XL's systems are installed on the chasses of delivery trucks produced by OEMs such as Ford, GMC, Chevrolet and Isuzu. XL does not manufacture its own branded electric vehicle.



EV Semi-Trucks

Semi-trucks come in many shapes and sizes and are used for both short and long haul routes. Heavy duty trucking used for transportation generates a significant amount of carbon emissions driving the most miles (except for passenger cars) using diesel as the fuel source. The industry is looking at several alternative fuel options to decarbonize. Electric batteries are one option. Hydrogen is another. Hydrogen is effective at decarbonizing semi-trucks because batteries by themselves are too heavy to be effective. Currently, there are less than 5 hydrogen fuel cell electric vehicles on the road. Hydrogen is simply too expensive as the cost is over $6 per kilogram. However, there are expected to be 230 hydrogen fuel cell semis on the road by 2030. Hydrogen fuel cell costs are expected to decline to $3 per kilogram. For perspective, hydrogen prices at $4 per kilogram is parity with $3.25 diesel per gallon[10].

Volvo is producing its VNR electric truck with range to travel 150 miles. Table 2 highlights several recent SPACs that have identified innovative ways to decarbonize the semi-truck including:

Table 2

Short Distance EV Semi Trucks						
Company	Technology	Driving Range (miles)	2021 Unit Sales	2024 Unit Sales	2025 Unit Sales	% of 2025 Sales
XOS	Hydrogen fuel cells	250-300	74	5,660	7,400	43%
HYZON	Electric battery	100-275	0	7,149	15,153	45%
THE LION ELECTRIC CO.	Electric battery	100-200	400	15,800	N/A	85%
Long Distance EV Semi Trucks						
Company	Technology	Driving Range (miles)	2021 Unit Sales	2024 Unit Sales	2025 Unit Sales	% of 2025 Sales
HYLIION	Battery+generator	1,3000	300	34,500	N/A	100%
NIKOLA	Hydrogen fuel cells	500-750	0	5,000	N/A	42%

Source: Company filings as of 6/30/2021

- Hyzon (NYSE: DCRB) is decarbonizing the shorter distance truck transportation sector by manufacturing a fuel cell electric vehicle (FCEV) that uses hydrogen fuel cells to power short haul semi trucks replacing diesel. How does a FCEV operate? FCEVs use fuel cells on board to convert hydrogen into electricity that powers the electric motor. Hyzon semi-trucks require smaller batteries to provide supplemental power since zero-carbon hydrogen is used as the primary power supply to the electric drivetrain. Hyzon projects semi-truck sales to ramp from 74 representing 87% of sales volumes in 2021 to 7,400 by 2025 (43% of total volume sales).
- XOS (NYSE: NGAC) – As highlighted above, XOS is focused on last-mile and return-to-base short haul truck that travel less than 200 miles per shift. XOS modular designed battery and proprietary cooling system optimizes battery performance. The first XOS semi-trucks will be delivered in 2022 with unit sales growing by over 800% annually by 2025 representing 45% of XOS 2025 unit sales.
- Lion (NYSE: LEV) is an EV bus manufacturer today representing 98% of its 2020 unit sales. Short haul trucks are expected to be unveiled in 2021 and 2022 growing to represent 85% of unit sales by 2024.
- Hyliion (NYSE: HYLN) – Hyliion sells electrified powertrain solutions that can be installed on any Class 8 long haul semi-truck. Hyliion's innovative solution replaces the powertrain of existing trucks rather than building its own brand of semi-truck. Hyliion's fully electric system replaces a traditional diesel powertrain. The electric powertrain paired with a battery system that is recharged by an onboard generator fueled by natural gas. The use of an onboard generator requires a smaller battery back so Hyliion's truck is cheaper than a battery-electric truck and a fuel-cell electric truck. Hyliion ERX truck will be fuel agnostic allowing for the use of renewable natural gas or hydrogen. Hyllion forecasts unit sales to increase by almost 400% annually from 2021 – 2024.
- Nikola Corporation (NYSE: NKLA) – Nikola provides a battery-electric vehicle and hydrogen fuel cell electric vehicle semi-trucks. Hydrogen fuel cells are discussed above. Nikola's fuel cell electric vehicle are expected to be available in 2023 and will represent 42% of 2024 unit sales while battery electric vehicles will grow from 600 units in 2021 to 7,000 in annual sales in 2024. In addition, Nikola plans to build a hydrogen refueling station network with 10 in place by 2023 and 24 by 2024.

Urban Air Mobility

The last and probably most futuristic decarbonization solution is urban air mobility. What does this mean? It's an air-taxi. A flying car. An urban electric jet. George Jetson and Hanna Barbera are the original investors. You might be laughing but the investors backing three urban air mobility companies that recently IPOed as SPACs highlighted below are no joke. In addition, Morgan Stanley estimates Urban Air Mobility to be a $1.5 to $3.0 trillion industry by 2040[11].

- Archer Aviation (NYSE: ACIC) is headquartered in Palo Alto, CA. Archer is developing a full scale electric vertical takeoff and landing (eVTOL) jet that is capable of traveling 60 miles at 150 miles per hour. Archer wants to reduce traffic congestion offering customers the fastest mode of transportation. For example, the commute from JFK to downtown Manhattan is 7 minutes in an Archer electric plane. Pricing is expected to be cheaper than Uber and the all-electric plane means there are zero emissions. Archer has partnered with United Airlines to deliver its eVTOL jet starting in 2024. Ken Moelis, founder of Moelis & Company is the Chairman of the Board.
- Joby Aviation (NYSE: RTP) is headquartered in Santa Cruz, CA. Joby's electric plane transports four passengers up to 150 miles at 200 miles per hour. Reid Hoffman, founder of LinkedIn, is an investor and board member of Joby. Joby's investor base includes Toyota, Intel, jetBlue, and Capricorn. Joby has a first mover advantage already receiving the first military airworthiness approval for an eVTOL jet. Joby expects revenue beginning in 2025.
- Lilium (NYSE: QELL) offers the highest capacity (7-seater) and lowest noise eVTOL jet in the market. Lilium's investor base includes global technology investors including Tencent and Baillie Gifford. For $65, Lilium expects its jet can transport customers from JFK to NYC. For $200, Lilium's jet is expected to provide service to the Hamptons from NYC. Lilium forecasts is 7-seat jet to cost $2.5 million while projecting $5 million of revenue per jet per year based on earning $15,000 in revenue per jet per day with each jet traveling 1,500 miles per day. Lilium is also working on a 16-seat jet as well. Revenue from this business model is expected in 2024.
- Vertical Aerospace (NYSE: BSN) proposes an eVTOL jet with a capacity of 5 people with zero carbon dioxide emissions that can travel 100+miles at an operating cost of $1.06 per seat mile. The investor base of Vertical Aerospace includes Microsoft, Rolls-Royce, Honeywell, and American Airlines. American Airlines and Virgin Atlantic have conditional pre-orders for up to 300 aircrafts with a targeted delivery date in 2024.

Battery Storage

The high energy density and lightweight nature of lithium batteries has helped to decarbonize the transportation and utility sectors. In the transportation sector, battery storage has propelled EV's from a concept to approximately 2% of the global electric feet today. In the utility sector, battery storage technology is used when the intermittent energy sources like wind and solar are unavailable expanding the use of wind and solar generation. In general, lithium-ion batteries are able to store electricity for up to 4 hours. The world's largest battery energy storage system is in Monterey County California owned by Vistra. The Moss landing energy storage facility is connected to power grid and began operating on December 11, 2020 with capacity of 300 MW/1200 MWH. Moss uses 4,500 stacked battery racks each with 22 individual battery modules.

Currently, lithium-ion is the primary chemistry used for battery storage accounting for 93% of storage capacity. Some scientists believe that lithium-ion has reached its maximum potential. In addition, expanded use of lithium-ion batteries increase the need of lithium and cobalt. Chile, Australia, and China account for 85% of the lithium supply and 70% of global cobalt output comes from the Republic of Congo[12].

Technological advancements in battery storage are the most significant energy technology that could change the game accelerating the pace of decarbonization. Bloomberg New Energy Finance (BNEF) forecasts energy storage market to grow to 1095 GW and 2,850 GWh by 2040 requiring $660 billion in investment over the next two decades[13]. Improved battery technology reduces battery anxiety likely increasing the adoption rate of EV transportation. In addition, larger battery capacity increases the amount of time that energy can be stored which increases use of solar and wind for electricity.

Table 3 below highlights the former SPACs that are looking to capture market share in the growing battery storage market using new and existing battery chemistries including:

Table 3 – Battery Storage Former SPACs

Company	Target Market	Year $100 million revenue	2021-2027 Revenue CAGR	Key Technology
QuantumScape	All Electric Vehicles	2026	512%	Solid state battery
microvast	Commercial Vehicles	2021	60%	Fast charge lithium-ion battery
ROMEOPOWER	Commercial Vehicles	2021	85%	Highest battery capacity
stem	Commercial & Industrial	2021	51%	Proprietary software
eos	Utilities	2022	170%	Zinc based battery
FREYR	EV Battery Component	2023	234%	Clean battery cell production
ESS INC	Electric Utility Storage	2024	196%	Iron flow battery
Solid Power	All Electric Vehicles	2026	84%	Solid state battery (sulfide)

Source: Company filings as of 6/30/2021

- QuantumScape (NYSE: QS) is developing a next generation battery chemistry that could significantly advance the utilization of battery storage. Lithium-ion appears to have reached its limits as lithium-ion battery capacity limits the range of many electric vehicles today to less than 300 miles creating range anxiety for current and future electric vehicle owners. Quantumscape has developed a lithium-metal-solid-state battery technology that could revolutionize battery storage. Solid-state batteries offer greater battery capacity, longer life, faster charging and greater safety when compared to conventional lithium-ion batteries. Solid state batteries have the potential to change the transportation sector similar to how Microsoft Windows changed the computing industry. Quantumscape has a partnership with Volkswagen and is building a pilot facility to manufacturer solid-state battery cells. The key difference is between the lithium-ion and solid state batteries is the host material. Solid state batteries increase the battery capacity by eliminating the host material reducing the size and weight of the battery cell. A solid-state battery increases the range of an EV passenger car by 50% to over 450 miles. In addition, solid-state batteries can charge 80% in 15 minutes compared to hours for lithium-ion batteries. Solid-state chemistry has been endorsed by Stanley Whittingham who won the Nobel Prize in chemistry for developing lithium ion batteries based on Quatumscape's test data and demonstration. Tech investors are also embracing the potential for solid state batteries with Bill Gates investing in Quantumscape. Quantumscape must prove that it can layer multiple batteries together and that it can to mass produce its battery technology. This will require investor patience as material revenues (>$100 million) won't be reached until 2026. Quantumscape's initial target market will be electric vehicles. However, solid state batteries could be used to store electricity as well. In the future, solid-state batteries may allow electricity to be stored for days rather than hours.
- Microvast (NYSE: THCB) is focused on providing an ultra-fast charging lithium-ion battery solution for commercial vehicles. Microvast lithium-ion batteries recharge in 10 -20 minutes. Microvast is growing revenues at an annual pace of 60% through 2027. Microvast plans to expand its revenue sources beyond commercial vehicles starting in 2024 by selling battery component parts (separator and cathode) to passenger vehicle battery manufacturers.
- Romeo Systems (NYSE: RMO) manufactures lithium-ion batteries for commercial vehicles. Romeo believes its battery capacity is the highest amongst its peers. Romeo is the primary battery provider for Nikola vehicles representing 66% of Romeo's 2022 revenues and will be a supplier for Lion EV Buses. Romeo was founded by leaders from Tesla, SpaceX, Amazon, and Apple.

- Stem (NYSE: STPK) touts itself as the first pure play smart energy storage company. Stem sells traditional battery hardware that stores energy using lithium-ion batteries. In fact, Stem has contracted the largest amount of storage capacity with 600 megawatt hours under contract or 75% market share in California. Competitors include: Tesla, Hyundai Electric and Fluence Energy. In addition to hardware, Stem offers its customers Athena. Athena is a proprietary software that analyzes multiple factors impacting the electricity grid. The software allows commercial and industrial customers to make better economic decisions when to release energy from their Stem battery back onto the grid and when to re-charge the battery.
- Eos Energy Enterprises (NYSE: EOSE) creates low cost battery storage solutions for the electric utility industry. The Eos battery is a zinc battery chemistry that stores electricity for three to twelve-hours. Eos batteries are sold to wind and solar generators looking to balance the grid. Zinc batteries are manufactured in the U.S. and do not require lithium and cobalt. Zinc batteries are lower cost than lithium-ion as zinc battery systems don't require equipment to control temperature (HVAC and heating needed to lithium-ion) or fire suppression equipment.
- Freyer Clean Battery Solutions (NYSE: ALUS) is a developer of clean battery cell materials. Freyer produces battery cell materials such as cathode, anode electrolyte, and separator materials that make up 32% of a lithium-ion battery. The battery cells are manufactured in Norway. Freyer is building four gigafactories by 2025 and six gigafactories by 2028 in Norway. Its Norway locations utilizes renewable energy to power its gigafactories that produce its battery materials.
- ESS Inc. (NYSE: GWH) is a provider of long-duration energy storage using an iron flow chemistry. Iron flow chemistry is expected to be cheaper than lithium-ion with a better track record of safely operating. ESS has partnered with Munich RE to launch industry first insurance coverage of flow batteries meaning that the battery modules come with up to 10 year extended warranty backed by Munich RE.
- Solid Power (NYSE: DCRC) employs the same solid-state battery technology similar to Quantumscape discussed above. Solid Power batteries remained charged longer and weight less than traditional batteries. Solid Power batteries are also safer than lithium-ion batteries as they use a solid electrolyte instead of a flammable liquid. Solid Power solid-state batteries are differentiated from Quantumscape in the choice of electrolyte. Solid Power uses sulfide electrolyte material that is expected to have higher conductivity between the anode and cathode as well as is easier to mass produce compared to the ceramic oxide electrolyte material used by Quantumscape.

Charging Stations

EV charging stations are essential infrastructure as the adoption rate of electric vehicles accelerates. There are approximately 44,418 charging stations with 113,385 charging ports available today[14]. Public charging ports are classified in three categories including:

- Level 1 (2% of total) – standard wall outlet of 120 volts that takes 20 – 40 hours to recharge
- Level 2 (81% of total) – typical EV plug in homes and garages of 240 volts requiring 5 – 11 hours to recharge
- Level 3 or DCFC (17%) – DC fast chargers. 360 volts. Quickest way to charge requiring 30 minutes to 1 hour to recharge

The global EV market is expected to grow at a 31% CAGR from 2020 through 2030. By 2030, EV sales are projected to account for almost 30% of all global vehicles sales. An increase in the number of EVs on the road requires expansion of the public charging network. The rise in EV sales is expected to require a 24x expansion of U.S. public charging port network to 2.4 million ports by 2040.

Table 4 below highlights the four former SPACs that offer investors a pure-play ways to invest charging stations.

Table 4 – EV Charging Stations

EV Charging Station Stock	Ticker	Current Number of Charging Ports	Annualized Revenue Growth (2024)	First Year of Positive EBITDA >$10M
volta	SNPR	• 1,627 charging ports • 3,014 screens	111%	2023
chargepoint	CHPT	• 42,182 charging ports	64%	2024
EVBOX	TPGY	• 190,000 charging ports	75%	2024
EVgo FAST CHARGING	CLII	• 1,827 charging ports of which 75% DC fast charger	120%	2024
TRITIUM	DCRN	• Global fast charge provider	79%	2023
wallbox	KCAC	• Future residential and transportation charger provider	84%	2024

Source: Company filings as of 6/30/2021

Each one of the EV charging stocks is differentiated. The key differences between the various companies are as follows:

	Key Differentiator
volta	• Supplemental revenue from screens
chargepoint	• Largest EV charging footprint in the U.S.
EVBOX	• Market leader in Europe with existing business with multinational corporations
EVgo FAST CHARGING	• Focus on DC fast charges in higher density urban areas
TRITIUM	• DC fast charger provider capable of 20 mile charge in 1 minute and 100-mile charge in 5 minutes
wallbox	• Smart charging for home use

A sixth former SPAC that is included in the charging stations category is **NUVVE Corporation (NYSE: NBAC)**. NUUVE is a start-up focused on vehicle-to-grid or (V2G) technology discussed above. NUVVE's technology monitors the EV battery power and regulates it based on customers ultimate daily usage need managed by the EV owner via a mobile fleet app. NUVVE has pilot projects underway in Africa, Europe, and the U.S.

Autonomous Vehicles Components (AVs)

Autonomous vehicle, self-driving car, driverless cars are all terms used to describe a significant innovation that could disrupt the transportation sector. Technology companies such as Tesla, Google, Uber, Microsoft, and Apple have experimented in development of autonomous vehicles. In addition, major automakers continue to commit research and development dollars to develop fully autonomous vehicles.

Waymo is the leading autonomous vehicle operator in the world. Waymo is preparing to launch a robotaxi service in California. Cruise, owned by General Motors, is preparing to launch a similar service.

A technology that is key to the future success of autonomous vehicles is LIDAR, an acronym for light detection and ranging. LIDAR is the technology used to control and navigate anything autonomous including passenger vehicles, delivery trucks, taxis, robots, etc.

Seven companies provide investors access to pure-play LIDAR technology stocks that became publicly traded via SPAC including:

NYSE: VLDR - Headquartered in San Jose, CA, Velodyne invented real-time 3D Lidar and its technology is currently used in AVs, advanced driver assistance systems, robotics and industrial, mapping, shuttles, smart city, delivery. The company forecasts 77% annual
revenue growth through 2024 in last mile delivery and robotaxi technology applications.

NYSE: LAZR – Headquartered in Palo Alto, CA, Luminar's stated goal is to make autonomous transportation sae and ubiquitous. Luminar's target market is passenger vehicles, trucking, and robo-taxis that utilize its 93 patents. The company's investor base includes legendary tech investors Peter Thiel, Alec Gores, Go-Pro founder Nick Woodman. Annual revenue is forecasted to grow by 103% through 2024.

NYSE: AEVA – Led by the former head of the sensing program at Apple, Aeva's 4D LIDAR technology is marketed as the most advanced data capturing sensing solution. Aeva's technology uses a chip rather than a device that industry leader Velodyne manufactures. AEVA believes its technology placed on a chip will make its product the lowest cost Lidar solution. VW has invested in Aeva and is considering Aeva's prouct for 2024 production. Aeva's primary market will be autos.

NYSE: CGRO – Based in Israel, Innoviz LIDAR technology has been selected by BMV for its fully electric autonomous car program. Innoviz believes its technology will be the first to be deployed in consumer vehicles. Innoviz forecasts autonomous vehicles could become a reality by 2029 – 2030. Innoviz products are designed for automakers, robotaxis, shuttle, and delivery companies. Investors include SoftBank Ventures Asia, Samsung, and Aptiv.

NYSE: OUST – Ouster creates products using LIDAR technology. Ouster touts itself as a low cost technology provider that caters to a broad array of customers including industrails, robotics, smart infrastructure, and automotive.

NYSE: CFAC – Aeye slogan is "Think like a robot, perceive like a human." Aeye believes its LIDAR technology has tested the best a detection of things like pedestrians, brick walls, and other vehicles. Cantor Fitzgerald CEO Howard Lutnick is Chairman of the Board and investors include Kleiner Perkins.

NYSE: CCAC – Quanenergy provides next-generation solid state LIDAR solutions. Quanenergy believes its developed the most reliable and lowest cost LIDAR solution to advance driveless cars in the automotive industry.

Other

Other includes four current SPACs that represent approximately 3% of the total former SPAC market cap. Stocks included in this category include the following:

- Archaea Energy (NYSE: RICE) operates nine renewable natural gas (RNG) projects. Archaea primarily captures methane from landfills and processes it into renewable natural gas used for transportation, electricity or combined with other technologies to produce green hydrogen. Archaea is one of the few former SPACs that generated positive EBITDA in 2020.
- ReNew Power (NYSE: RMBG) is India's largest renewable energy company and the 12th largest wind and solar operator in the world based on net (operational + committed) capacity of 10 gigawatts.
- Li-Cylce (NYSE: PDAC) is largest lithium-ion battery recycler in North America.
- Origin (NYSE: AACQ) uses bio-feedstocks such as pulp waste, cardboard, wood chips, whole cane, and rice hulls to produce petrochemicals like chloro-methyl-furfural (CMF) used to manufacture textiles, fabrics, paints, tires, and agricultural products.
- Sunlight Financial (SPRQ) provides financing for installation of residential solar systems.

Before concluding, there are several other energy-technologies that are not yet represented via SPACs. Energy-technologies such as carbon capture, renewable natural gas, renewable diesel, and hydrogen infrastructure including electrolyzers could make a significant contribution toward accelerating the pace of decarbonization as well.

Conclusion

Technology and innovation will drive the pace of decarbonization. The economic incentives to disrupt the global energy sector are in place as an over $11 trillion total addressable market is significant. The social benefits of achieving net zero by 2050 are momentous. Energy-technology stocks that became publicly-traded entities via a SPAC offer an opportunity to invest in several pure-play technologies that have the potential to change the game over the next decade.

SPAC Universe

Below is a list of former SPACs that have become energy-technology companies as well as current SPACs that have identified target companies as of June 30, 2021.

Table 5 Listed Energy-Technology Companies that started as SPACs

SPAC Ticker	SPAC Name	De-SPAC Ticker	De-SPAC Company Name	Sector
SBE	Switchback Energy Acquisition Corporation	CHPT	ChargePoint	Charging Station
CLA	Colonnade Acquistion Corporation	OUST	Ouster Inc	Autonomous Vehicles Components
CGRO	Collective Growth Corporation	INVZ	Innoviz Technologies	Autonomous Vehicles Components
STPK	Star Peak Energy Transition Corporation	STEM	Stem	Battery Storage
NGA	Northern Genesis Acquistion Corporation	LEV	Lion Electric	EV Transportation
CIIC	CIIG Merger Corporation	ARVL	Arrival	EV Transportation
NBAC	Newboard Acquisition Corporatin	NVVE	Nuvve Corporation	Charging Station
IPV	Inter Private Acquistion Corporatin	AEVA	Aeva, Inc	Autonomous Vehicles Components
KCAC	Kensington Capital Corporation	QS	Quantumscape Corporation	Battery Storage
RMG	RMG Acquisition Corporation	RMO	Romeo Systems Inc.	Battery Storage
PIC	Pivotal Investment Corporation II	XL	XL Fleet	EV Transportation
BMRG	B. Riley Principal Merger Corporation II	EOSE	Eos Energy Enterprises	Battery Storage
GMHI	Gores Metropoulos	LAZR	Luminar	Autonomous Vehicles Components
HCACU	Hennessy Capital Acquistion Corporation IV	GOEV	Canoo	EV Transportation
DPHC	DiamondPeak Holdings Cororation	RIDE	Lordstown	EV Transportation
SPAQ	Spartan Energy Acquistion Corporation	FSR	Fisker	EV Transportation
GRAF	Graf Industrial	VLDR	Velodyne Lidar	Autonomous Vehicles Components
SHLL	Tortoise Acquistion Corporation	HYLN	Hyliion Corporation	EV Transportation
VTIQ	VectorIQ Acquisition Corporation	NKLA	Nikola Corporation	EV Transportation

Table 6 Listed Energy-Technology Companies that are currently SPACs with identified targets

SPAC Ticker	SPAC Name	Post-Business Combination Ticker	De-SPAC Company Name (once business combination is complete)	Sector
DCRN	Decarbonization Plus Acquisition Corporation II	DCFC	Tritium	Charging Station
STWO	ACON S2	GWH	ESS Inc	Battery Storage
RICE	Rice Acquistion Corporation	LFG	Archaea Energy	Renewable Natural Gas
QELL	Qell Acquisition Corporation	LILM	Lilium GmbH	EV Transportation
RMGB	RMG Acquistion Corporation II	RNW	ReNew Power	Wind and Solar Generation
RTP	Reinvent Technology Partners		Joby Aviation	EV Transportation
CCIV	Churchill Capital IV	LCID	Lucid Motors	EV Transportation
NGAC	NextGen Acquisition Corporation	XOS	XOS	EV Transportation
AACQ	Artius Acquisition Inc	ORGN	Origin	Renewable Chem
CFAC	CF Finance Acquisition Corp II		Aeye	Autonomous Vehicles Components
PDAC	Peridot Acquisition Corporation	LICY	Li-Cycle	Lithium-ion recycler
ACIC	Atlas Crest Investment Corporation	ACHR	Archer Aviation	EV Transportation
DCRB	Decarbonization Plus Acquisition Corporation	HYZN	Hyzon	EV Transportation
SNPR	Tortoise Acquisition Corporation II	VLTA	Volta	Charging Station
THCB	Tuscan Holdings Corporation	MVST	Microvast	Battery Storage
ALUS	Alussa Energy Acquistion Corporatoin	FREY	FREYER Clean Battery Solutions	Battery Storage
PSAC	Property Solutions Acquisition Corporation	FFIE	Faraday Future	EV Transportation
SPRQ	Spartan Acquisition Corporation II		Sunlight Financial	Rooftop Solar
CLII	Climate Change Crisis Real Impact I Acquisiton Corp	EVGO	EVgo	Charging Station
ACTC	Ardlight Clean Transition Corporation	PTRA	Proterra	EV Transportation
FIII	Forum Merger III Corporation	ELMS	Electric Last Mile Solutions	EV Transportation
TPGY	TPG Pace Beneficial Finance Corporation	EVB	EVBox Group	Charging Station

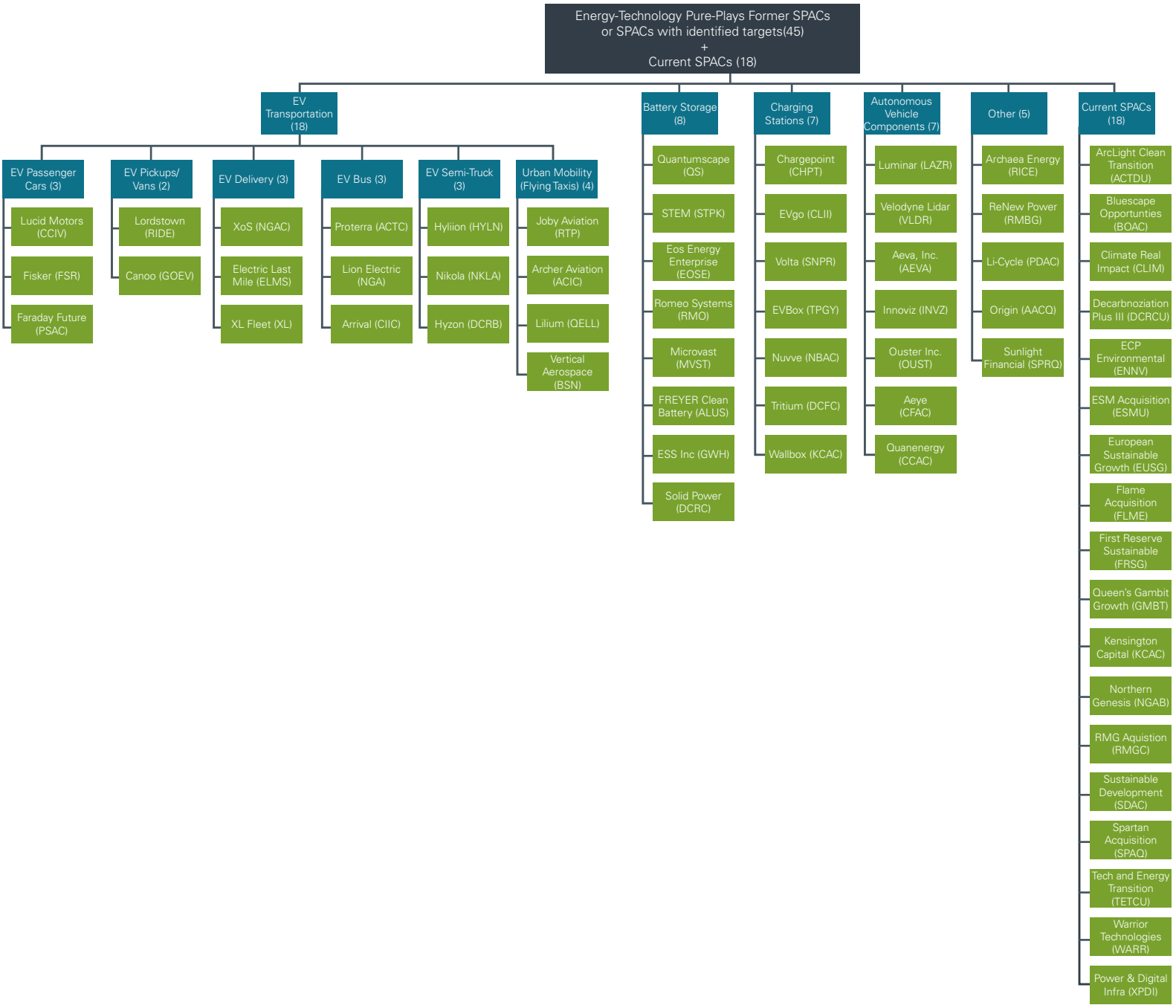
SPAC Universe

The list below highlights current SPACs that have yet to identify an energy-technology company to merge with.

Table 7 Current SPACs

SPAC Ticker	SPAC Name
ACTDU	ArcLight Clean Transition Corporation II
CLIM	Climate Real Impact Solutions II Acquisition Corporation
DCRN	Decarbonization Plus Acquisition Corporation II
ENNV	ECP Environmental Growth Opportunities Corporation
ESMU	ESM Acquisition Corporation
EUSG	European Sustainable Growth Acquisition Corporation
FLME	Flame Acquisition Corporation
FRSG	First Reserve Sustainable Growth Corporation
GMBT	Queen's Gambit Growth Capital
KCAC	Kensington Capital Acquisition Corporation II
NGAB	Northern Genesis Acquisition Corporation II
RMGC	RMG Acquisition Corporation III
SDAC	Sustainable Development Acquisition I Corporation
SPAQ	Spartan Acquisition Corporation III
TETCU	Tech and Energy Transition Corporation
WARR	Warrior Technologies Acquisition Corporation
XPDI	Power & Digital Infrastructure Acquisition Corporation

SPAC Landscape



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