Taiga Ekko Mountain

Silent-Yachts 120 Explorer

Fendt e100 Vario

A Pocket Guide to Electric Transportation

SeaMagine Aurora-100

Bunch Bike

Rolls Royce Silent Shadow

REDWOOD ENERGY

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Check out Redwood Energy's Commercial, Multifamily and Single-Family Zero Carbon All-Electric Guides at their website:
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Table of Contents

Introduction

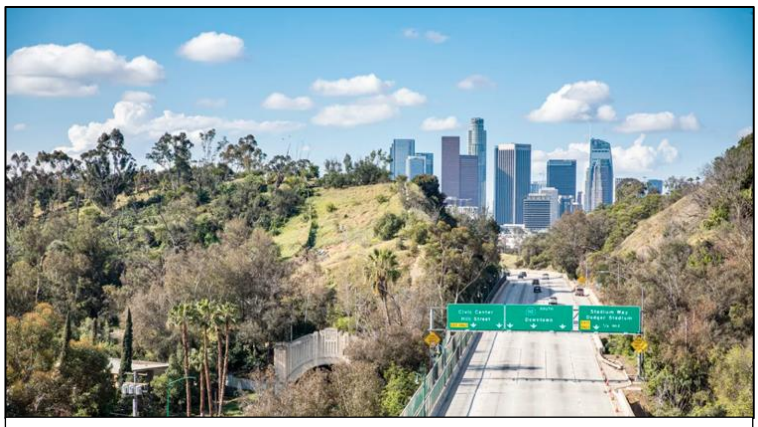


Figure 1: With no vehicles on the road and industry halted, the clear blue skies over Los Angeles in March, 2020 showed what an all-electric future can look like. Twitter/@MikeSington

Electrifying transportation is the world's single largest climate change challenge, causing about 28% of total greenhouse gas emissions[1] and 45% of smog-causing nitrogen oxides.[2] More than half of these emissions come from passenger vehicles and light/medium/heavy duty trucks.[1] Globally, about 75% of CO_2 emissions from transportation are from road vehicles[3] (Fig. 2).

This pocket guide is intended to help you buy electrically and make better public policies. From your personal car to rented construction equipment and from jet skis to cargo bikes.

Commonly Asked Questions and Answers:

Q. Are there limits to transportation electrification?

A. Only space shuttles. Semi-trucks, trans-atlantic barges, jet engines, construction equipment and more all have electric replacements deployed or in development.

Q. Really? Even **electric jet airplanes**?

A. Yes, back in 2017 Norway's national airline, Avinor, announced a 2025 target for their first electric flights,[4] and they are **on track for delivery in 2026**.[5] European manufacturer Airbus has a 2035 target for electric jets. Rather than wait for electric airplanes, in 2022 France required train use by banning fueled flights of less than 2.5 hours.[6] Private jets burn six times as much fuel per person as public trains.[7]

Q: What about the environmental and social impacts of **mining battery minerals**?

A: They're real, but **coal and oil mining destroy roughly 500 times more land**.[8] A car battery is refilled at least 10,000 times before recycling, and usually many thousand times more.

Q: Can American homes handle 100% electric vehicles without a new electrical service from the utility?

A: Yes. **Existing wires and transformers to most homes are right-sized for adding electric vehicle chargers** (e.g. 20A on a 100A panel, 40A on a 200A panel). Bidirectional EVs can also help add capacity to the grid during summer heat waves.

Q: Can American public parking lots support 100% EV chargers without new electrical services?

A. Parking lots rarely have more power than needed for lighting, so charging many vehicles in one spot usually requires new utility wiring to the site. However, **cities like Seattle and London have installed EV chargers on residential streets attached to light posts**—they are relatively slow, but available without adding new utility services.

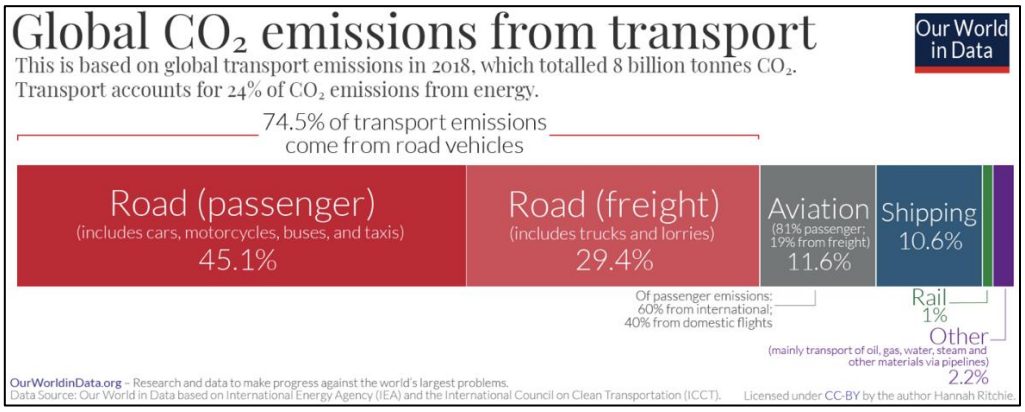


Figure 2: From Our World in Data, passenger vehicles alone contribute 45% of global CO_2 emissions from transportation.

Delivering Packages and People

Driven by legislation, government agencies and board or CEO commitments, 2040 is the latest date most of America's largest delivery fleets have announced full electrification, but many are moving faster. Amazon has targeted 2030 and has 100,000 on pre-order with Rivian,[9] while the U.S. Postal Service is making 60% of their purchases electric staring in 2022.[10] UPS has ordered 10,000 electric vans made by Arrival,[11] and even Domino's Pizza started electrifying their fleet in 2015 and are buying another 800 Chevy Bolts in 2023.[12] FedEx and Walmart both have electric prototypes already in service.[13]

Figure 3: Amazon co-owns and has ordered 100,000 Rivian delivery vans for 100% fleet electrification by 2030.

Figure 4: Domino's already has almost 500 Chevy Bolts in their pizza delivery fleet as of February 2023.

Similarly, ride-hailing and chaeffeur businesses in the State of California are responding to a law that requires all ride sharing services (Lyft, Uber, Yellow Cab, limousine services, etc.) to be all-electric by 2030.[14] Because California's vehicle emissions regulations have been legislatively adopted by 14 states and the District of Columbia, this 2030 mandate for zero-emissions ride sharing has national and international impacts.[15]

Many ridesharing companies have been actively shifting to electric vehicles. In 2021 Revel started a new electric-only ride-hailing service in Manhattan, an expansion of Revel's existing electric bike and scooter rental business.[16] Similarly, Lyft has promised 100% electric vehicles by 2030[17] with 4,000 Lyft drivers in London by 2021[18] and EVs in Atlanta, Denver, Seattle and San Francisco.[19] Uber now pays a premium to its electric vehicle drivers and has promised 50% of their drivers will have electric vehicles by 2025, and 100% by 2040.[20] Rolls Royce has promised its limousines will be exclusively electric by 2035.[21]

Figure 5: (top) Lyft has deployed more than 4000 new Teslas in London since 2021, while Lunaz has been electrifying classic limousines like the 1961 Rolls Royce "Phantom" (middle) that includes bar service for eight guests, gold inlay and a motorized partition. Rolls Royce unveiled its new "Silent Shadow" self-chauffeuring electric limousine (bottom), a concept car that comes with matching blue luggage and gull wing doors.

Electric Outdoor Recreation

Figure 6: Electric snowmobiles for an Arctic safari with Safarctica.

The reindeer who live around the hometown of Santa Claus in Rovaniemi, Finland, run from two-stroke engine gas snowmobiles. But since 2017 Aurora Powertrains[22] has been selling silent, retrofitted electric snowmobiles to ecotourism businesses like Safarctica[23] for visits to the Reindeer herds and witnessing the magical Aurora Borealis without a sound. Electric snowmobiles are silent except for the crunching snow, quiet enough that an old tourism industry can add a new business service.

In North America a purpose-built electric snowmobile by Taiga came to market in 2021 and the snowmobile tour businesses in Yellowstone National Park, which restricts snowmobiles only to high-cost 4-stroke engines due to noise,[24] have contributed to a one-year backorder on Taiga electric snowmobiles.[25] Taiga's electric jet ski is built on the same platform as the snowmobile, quietly racing at 60 miles/hour for two hours per charge.

Figure 7: Taiga's three models of electric snowmobiles accelerate to 60mph in 3 seconds, as fast as a Tesla, but make no sound but crunching snow. Taiga's electric "Orca" jet skis cruise at 60mph and make no sound but splashing water and people laughing.

Electric Construction Equipment Rentals

Cities world-wide have been requiring mitigation measures that favor electric equipment, such as requiring diesel emission control devices, limiting engine idling time and reducing construction periods to avoid noise complaints.[26] To reduce air pollution, Oslo, Norway is requiring all construction sites to produce zero emissions by 2025, essentially mandating electric equipment.[27] Even when diesel equipment is still allowed, fines for contributing to local air pollution can be a significant construction cost—the Sacramento Air Quality Management District sets a rate of $30,000 per ton of construction emissions.[28]

Figure 8: Electric options for heavy equipment are becoming move available.

More than 60% of all earthmoving and road building equipment in North America is rented rather than owned by the contractors, and this $40B per year business has been rapidly adopting electric equipment to give contractors access to the equipment with the best safety features, lower operating costs, fewer breakdowns and much less noise.[29] Rental companies advertising just electric construction equipment can be found in climate-conscious cities like Boston,[30] while the nation-wide rental firms are quickly phasing in electric equipment while phasing out gas, newly offering electric bull dozers, loaders, cranes, excavators, back hoes, concrete grinders, mortar mixers, rough terrain forklifts, scissor lifts, pallet jacks, air compressors, power washers and more.[31]

Electric Flight

The airplane industry is responsible for around 12% of transportation emissions in the US, and 3% of global greenhouse gas emissions.[32] Norway has led the response, requiring all flights of 1.5 hours or less to be all-electric by 2040.[33] Most airports in the U.S. are owned by municipalities or counties, many of which have committed to reduce greenhouse gas emissions such as jet fuel, also known as Diesel or Kerosene, to clean alternatives. Requiring electric aviation at a known future date allows airline manufacturers time to transition their designs, which takes about seven years including testing and certification by the FAA.[34] One to three hour flights can be served with current electric aircraft technology—enough for Californians to fly anywhere in the state and to neighboring Nevada and Oregon—and rapid improvements to energy density and a wide range of experimental batteries provide optimism for longer range flights in the coming decades.

Figure 9: Wright Electric is working with Honeywell and EaglePicher, along with NASA and the U.S. Department of Energy, to advance the capacity of their electric aircraft.[35]

Vehicle to Home and Vehicle to Grid Charging

Vehicle-to-Home Charging was developed in Japan after the 2011 tsunami closed the nation's nuclear power plants. Nissan pioneered the concept of **"Vehicle-to-Home" (V2H)** which uses a charger to isolate a home from the grid and draws on the vehicle's battery power for its electrical needs when utility grid power is not available. Nissan estimates that its all-electric Leaf can power an average home in Japan for two to four days without solar,[36] and with rooftop solar the system is sufficient for off grid living most of the year. The term **"Vehicle-to-Grid" (V2G)** describes the situation where the car's excess electricity is provided to the utility grid. The International Energy Agency estimated that in 2030 there will be 130 million electric vehicles on the road, which will contain almost ten times the amount of energy storage needed for a renewably powered grid.[37]

Nuvve Available Now, Others Available Soon in the United States

	Wallbox[38] Quasar2	**dcbel**[39] r16	**Nuvve**[40] PowerPort	**BorgWarner**[41]	**Fermata Energy**[42]
					
Vehicle-to-Home	X	X	X	X	X
Vehicle-to-Grid	X		X	X	X
Other Features	• It charges and discharges through a CCS vehicle connector • Max power of 11.5 kW	• Also operates as a solar inverter and home energy management system • CHAdeMO and CCS	• 6-80 Amps of Single Phase AC charging • J1772/IEC 62196	• Max power of 60 or 125 kW • Made for med/ heavy duty EVs with large batteries such as school buses	• Commercial and residential capabilities

Not Available in the United States

Since at least 1996 there have been a plethora of companies outside the United States have V2H and V2G chargers. They are used during power outages and to provide grid services. Using a car's battery to power your home or to sell back to the grid is an essential service in our all-electric future.

Vehicle to Building (V2B) Chargers			**Vehicle to Grid (V2G) Chargers**			
Honda	**Mitsubishi**	**Nissan**	**Nissan**	**Endesa**	**OVO**	**Princeton Power Systems**
						

Transportation

Electric Cargo Bikes

The first cargo bikes in the late 1800s were human powered and constructed specifically to transport loads by tradesmen delivering mail, bread, milk, and other goods. Today, electric cargo bikes integrate a 500Wh to 1000Wh battery and an electric motor propels the rider and their cargo 15-25 mph, and 20-125 miles per charge, for as little as $.05 and as much as $.30, depending on the local utility cost—literally pennies. A car weighs thousands of pounds, and costs 25 times or more in electricity to go the same distance as a cargo bicycle.

Cargo bikes vary on where they place the weight, how they steer, how much they hold and how many wheels are used. Many models include not only cargo areas for the transport of goods, but leash hookups for pets and seating with seat belts for children. The popularity of E-cargo bikes is on the rise: according to Persistence Market Research, "The global electric cargo bikes market is estimated to be valued at US$ 402.7 Mn by the end of 2018 and reach US$ 1,095.2 Mn by the end of 2026."[43]

			
Name	**The Original 3.0 – Bunch Bikes**	**Supercargo CL -Yuba**	**The Preschool 3.0 – Bunch Bikes**
Payload Capacity	350 lb	440 lb	350 lb
Battery	652.8 Wh	500 Wh	652.8 Wh
Motor	500W	250W	500W
Range	25-35 miles per charge	Up to 60 miles per charge	25-35 miles per charge
Charge Time	4-6 Hours	4.5 Hours	4-6 Hours
Max Speed	15-20 mph	20 mph	15-20 mph
Price	$4,285	$5,999	$4,785

			
Name	**Radwagon 4 – Rad Power Bikes**	**GSD S00 LX – Tern Bicycles**	**Stoker – Xtracycle**
Payload Capacity	350 lb	440 lb	400 lb
Battery	672 Wh	Single 500 Wh or Dual 1000 Wh	630 Wh
Motor	750W	36V/250W	250 W
Range	25-45+ miles per charge	500Wh 31-63 miles 1000Wh 63-128 miles	30-60 miles per charge
Charge Time	3-7 Hours	4.5 Hours	7-10 hours
Max Speed	20 mph	20 mph	20 mph
Price	$1,699	500Wh - $6,799 1000Wh - $7,499	$4,999
			
Name	**Packa Genie - Blix**	**Payload - Magnum**	**XP Step-Thru 3.0 – Lectric**
Payload Capacity	400 lb	300 lb	330 lb
Battery	1,228 Wh (2 batteries of 614 Wh)	1008 Wh	500 Wh
Motor	750W	500W	500W
Range	40 miles with single battery 80 miles with dual batteries	30-60 miles per charge	45 miles per charge
Charge Time	6 Hours	10.5 Hours	4-6 Hours
Max Speed	20 mph	20-25 mph	20 mph
Price	$2,099	$2,899	$999

Electric Vehicles

In California, the greatest percentage of smog and greenhouse gas emissions in the state comes from fuel burning vehicles. Electric vehicles create no direct air pollution, rely on a grid in California that is 50% renewables, and use just 1/3 the energy of gas engines. Electric vehicles are the key to reducing the carbon impact of driving, and their battery systems can provide resilience to your home by running critical electric loads when the power goes out. The below section provides a list of electric vehicles with their specifications, provided by MenloSpark in March 2023.[44]

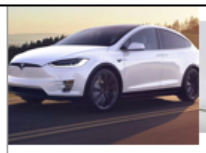
					
Manufacturer	**Audi**	**Audi**	**BMW**	**BMW**	**Cadillac**
Model	**Q4 e-tron**	**e-tron quattro**	**i4**	**iX Drive 50**	**LYRIQ**
Passengers	5	5	5	5	4
Doors	5	5	5	5	5
MSRP (from)	**$49,800**	**$71,995**	**$55,900**	**$85,095**	**$61,795**
Car Body	SUV/Crossover	Standard SUV 4WD	Sedan	SUV	SUV
EPA Range (miles)	265	226	270	324	312
MPGe City / Highway	112/94	78/79	109/108	86/86	97/82
MPGe Combined	103	79	109	87	89
Battery Capacity (from)		95 kWh	83.9 kWh	105.2 kWh	102 kWh
Horsepower			335.3		500
0-60 Speed	8 seconds	5.5 seconds	5.7 seconds	4 seconds	4.6 seconds
Charge Time (240 volt)	10.7 hours	9 hours			
DC Fast Charge Time		80% in 30 min		80% in 35 min	
Max Cargo		57 cu ft	45.56 cu ft	61.8 cu ft	60.81 cu ft

					
Manufacturer	**Chevrolet**	**Chevrolet**	**Fisker**	**Ford**	**Genesis**
Model	**Bolt EV**	**Bolt EUV**	**Ocean Sport**	**F-150 Lightning**	**GV70**
Passengers	5	5	4	5	5
Doors	5	5	5	4	5
MSRP (from)	**$37,495**	**$37,495**	**$37,499**	**$57,869**	**$65,000**
Car Body	Hatchback	Hatchback	SUV	Truck	SUV/Crossover
EPA Range (miles)	259	247	273	240	236
MPGe City / Highway	131/109	125/104		76/61	97/82
MPGe Combined	120	115		68	90
Battery Capacity (from)	65 kWh	65 kWh	80 kWh	98 kWh	77 kWh
Horsepower	201.2	201.2		426	
0-60 Speed	6.5 seconds	7 seconds	6.9 seconds		4 seconds
Charge Time (240 volt)					10 hours
DC Fast Charge Time			80% in 35 min		
Max Cargo	56.9 cu ft	56.89 cu ft	25 cu Ft	52.8 cu ft	

					
Manufacturer	**GMC**	**Hyundai**	**Hyundai**	**Jaguar**	**Kia**
Model	**Hummer EV**	**Ioniq 6**	**Kona Electric**	**I-Pace S**	**Niro EV**
Passengers	5	5	5	5	5
Doors	4	4	4	4	4
MSRP (from)	**$87,000**	**$56,100**	**$33,550**	**$72,575**	**$40,875**
Car Body	Truck	Sedan	SUV/Crossover	Sedan	Crossover
EPA Range (miles)	329	220	258	246	253
MPGe City / Highway	51/43		134/106	89/82	126/101
MPGe Combined	47	121	120	85	113
Battery Capacity (from)		77.4 kWh	64 kWh	90 kWh	64.8 kWh
Horsepower	1000	221	214	197	201
0-60 Speed	3.3 seconds	5.1 seconds	8 seconds	4.3 seconds	6.7 seconds
Charge Time (240 volt)			9 hrs, 10 min		
DC Fast Charge Time		80% in 18 min	80% in 41 min	80% in 40 min	80% in 45 min
Max Cargo	11 cu ft	14.2 cu ft	39.3 cu ft	26 cu ft	23 cu ft

						
Manufacturer	**Kia**	**Lucid**	**Lucid**	**Mercedes Benz**	**Mini**	**Nissan**
Model	**EV6**	**Air Grand Touring**	**Air**	**EQE**	**Cooper SE**	**Ariya**
Passengers	5	5	5	5	2	
Doors	4	4	4	4	4	
MSRP (from)	**$48,700**	**$138,000**	**$92,900**		**$30,900**	**$43,190**
Car Body	SUV	Sedan	Sedan	Sedan	Sedan	Wagon
EPA Range (miles)	232	469		387	114	216
MPGe City / Highway	134/101	121/122	140/141		119/100	109/94
MPGe Combined	117	121	140		110	101
Battery Capacity (from)	77 kWh	112 kWh	92 kWh	89 kWh	63 kWh	63 kWh
Horsepower			480	241	181	224
0-60 Speed	7 seconds	3.0 seconds	3.8 seconds	7.3 seconds	6.9 seconds	7.5 seconds
Charge Time (240 volt)	10 hours					
DC Fast Charge Time	80% in <1 hour			80% in 32 min	80% in 36 min	
Max Cargo	45.9 cu ft	16.1 cu ft		31.6 cu ft		

						
Manufacturer	**Polestar**	**Porsche**	**Rivian**	**Rivian**	**Subaru**	**Tesla**
Model	**Polestar 3**	**Taycan**	**R1S**	**R1T**	**Solterra**	**Model S**
Passengers	5	4	5	4	5	5
Doors	5	4	5	5 or 7	4-Jan	4
MSRP (from)	**$83,900**	**$88,150**	**$78,000**	**$73,000**	**$44,995**	**$94,990**
Car Body	SUV	Sedan	SUV	Truck	SUV	Sedan
EPA Range (miles)	300	208	321	314	228	405
MPGe City / Highway		79/88	75/66	76/69	114/94	124/115
MPGe Combined		83	71	73	104	120
Battery Capacity (from)	111 kWh	79.2 kWh	135 kWh	128.9 kWh	72.8 kWh	100 kWh
Horsepower			600	835	107	518
0-60 Speed	5 seconds	5.1 seconds	4.5 seconds	4.5 seconds	4.5 seconds	3.1 seconds
Charge Time (240 volt)	11 hours				11 hours	8.75 hours
DC Fast Charge Time	80% in 30 min			80% in 41 min		80% in 40 min
Max Cargo	50 cu ft	16 cu ft	105 cu ft	37 cu ft	63.5 cu ft	58.1 cu ft

						
Manufacturer	**Tesla**	**Tesla**	**Tesla**	**Toyota**	**Volkswagen**	**Volvo**
Model	**Model X**	**Model 3**	**Model Y**	**bZ4X**	**ID.4 Pro**	**C40 Recharge**
Passengers	5 to 7	5	5 to 7	5-Jan	5	
Doors	4	4	4	4	5	
MSRP (from)	**$104,990**	**$43,990**	**$52,990**	**$42,000**		**$55,300**
Car Body	SUV	Sedan	SUV	SUV	SUV	SUV
EPA Range (miles)	348	272	279	252	275	226
MPGe City / Highway	107/97	138/126	127/117	131/107	115/98	94/80
MPGe Combined	102	132	123	119	107	87
Battery Capacity (from)	100kWh	60 kWh			77 kWh	80 kWh
Horsepower	502.9+258.8	283		201		
0-60 Speed	3.8 seconds	5.8 seconds				4.7 seconds
Charge Time (240 volt)	5.75 - 8.75 hours	5.75 hours		9.5 hours		
DC Fast Charge Time	80% in 50 min	80% in 30 min		80% in 30 min		
Max Cargo	81.21 cu ft	12 cu ft		16 cu ft		

Electric Semis and Other Large Trucks

	BYD 8TT Tandem Axle	**Daimler** Freightliner eCascadia	**Nikola Corp** Tre BEV	**Tesla** Semi
				
Horsepower	483 hp	Tandem Drive: 470 hp Single Drive: 395 hp	645 hp	--Not Listed--
Torque	664 lb-ft	Tandem: 23,000 lb-ft Single: 11,500 lb-ft	--Not Listed--	--Not Listed--
Mile Range	124-167 miles per charge	155-230 miles per charge	330 miles per charge	300 or 500 miles per charge
Battery Capacity	422 kWh	291 kWh or 438 kWh	733 kWh	~850 kWh
Recharge	2.5 hours	80% in 90 minutes	80% in 90 minutes	70% in 30 minutes
Cost	$299,000	--Not Listed--	--Not Listed--	$180,000 (expected base price, 500 mile range)
	Mack MD Electric	**Volvo** FL Electric	**Workhorse** W750	**Kenworth** T680E
				
Horsepower	260 hp	175 – 248 hp	200 hp	670 hp
Torque	1,850 lb-ft	313 lb-ft	--Not Listed--	1,623 lb-ft
Mile Range	140 or 230 miles	186 miles per charge	150 miles per charge	150 miles per charge
Battery Capacity	150 kWh (2 batteries) 240 kWh (3 batteries)	200-395 kWh (3-6 batteries)	118 kWh	396 kWh
Recharge	100 or 160 minutes	2 hours	3-4 hours	3.3 hours
Cost	--Not Listed--	--Not Listed--	--Not Listed--	--Not Listed--

Electric Refuse Trucks

	Mack LR Electric	**Crane Carrier** LET2 EV	**Lion** Lion8 – Refuse Truck	**BYD** 8R-ER Refuse Truck
				
Horsepower	536 hp	500 hp	470 hp	402 hp
Torque	4,051 lb-ft	--Not Listed--	--Not Listed--	812 lb-ft
Mile Range	100 miles per charge	100-130 miles per charge	170 miles per charge	125 miles per charge
Battery Capacity	376 kWh	240 or 400 kWh	336 kWh	403 kWh
Recharge	2 hours	80% in 3.2 hours	2-4 hours	3.5 hours

Electric Ice Resurfacers

	Zamboni Model 650 Electric 	**Olympia** Millennium E Resurfice 	**Engo** IceWolf PRO 	**LSK** WM evo^2 
Blade Width	77 in	84 in	79 in	90.5 in
Water Capacity	260 gallons	253 gallons	264 gallons	317 gallons
Snow Volume	106 cu ft	103 cu ft	106 cu ft	145 cu ft
Battery	Lead Acid or Li-Ion Various Capacities	62 kWh	70 kWh	--Not Listed--
Motor Power	17.9 kW	16 kW	--Not Listed--	33 kW

Electric Low Speed Buses

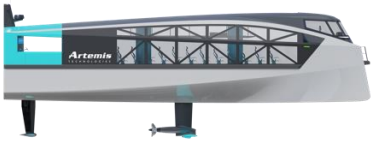
	Moto Electric Vehicles ETB-9PHD 	**Moto Electric Vehicles** ETB-23P 	**Specialty Vehicles** ECO-11 
Passengers	Up to 9	Up to 23	Up to 11
Range	Up to 50 miles	Up to 75 miles	Up to 60 miles
Speed	Up to 25 mph	Up to 20 mph	Up to 20 mph
Price	$28,995	$40,995	--Not Listed--

Electric Buses

	BYD C10MS – 45’ Coach Bus	**ARBOC** Equess Charge	**GreenPower** EV250 Transit Bus
			
Battery Capacity	446 kWh	350 or 437 kWh	210 kWh
Range	Up to 159 miles	Up to 210 or 230 miles	150-200 miles
Passengers	Up to 78 2 wheelchairs	Up to 25 or 33 4 or 6 wheelchairs	Up to 21 2 wheelchairs
Weight	Class 8	Class 7	Class 8
Length	45 ft	30 or 35 ft	30-39 ft
Top Speed	65 mph	--Not Listed--	--Not Listed--
Charge Time	3-3.5 hours	--Not Listed--	--Not Listed--

	Motor Coach D45 CRT LE CHARGE	**New Flyer** Xcelsior CHARGE NG™	**Proterra** ZX5 Electric Transit Bus
			
Battery Capacity	389 kWh	520 kWh	Up to 738 kWh
Range	170+ miles	Up to 152 miles	Up to 340 miles
Passengers	Up to 54	Up to 61 2 wheelchairs	Up to 40
Weight	Class 8	Class 8	Class 8
Length	45 ft	60 ft	40 ft
Top Speed	--Not Listed--	--Not Listed--	65 mph
Charge Time	Less than 4 hours	--Not Listed--	2-3 hours

Electric Ferries

	Artemis Technologies EF-24 Passenger	**Candela** P-12	**EFerry** "Ellen"
			
Battery Capacity	--Not Listed--	--Not Listed--	4.3 MWh
Range	115 nautical miles	60 nautical miles	22 nautical miles (current route)
Passengers	150 passengers + 3 crew Storage for 18 bikes	30 commuters	147-196 passengers + 3-4 crew 31 cars
Speed	Up to 38 knots	60 km/h	14.2 knots

	Incat Tasmania Utility Ro-Pax Ferry	**Corvus Energy** MF Ampere	**Hydrolift Smart City Ferries** Hyke
			
Battery Capacity	--Not Listed--	1.5 MWh	285 kWh
Range	100 nautical miles	--Not Listed--	--Not Listed--
Passengers	2100 people (including crew) 226 vehicles	350 people 120 vehicles	50 people
Length	486 ft	250 ft	49 ft
Speed	20-25 knots	--Not Listed--	15 knots

Zero Emissions Planes

	Bye Aerospace eFlyer4 	**Pipistrel** Alpha Electro 	**Harbour Air/Magnix** 
Range	253 miles at 110 mph 2-3 hours	86 miles Up to 60 minutes	30 min flights
Flight Capacity	4-Seater	2-Seater	6-19 People
Cruising Speed	70-230 mph	98 mph	Max: 112 mph
Notes	All-Electric $627,000	All-Electric	All-Electric retrofit of the de Havilland Canada DHC-2 Beaver
	Ampaire Electric EEL 	**Raytheon Technologies** 	**Faradair** The Bio-Electric Hybrid Aircraft 
Range	200 miles (Battery)	--Not Listed--	1,150 miles combined (battery only not listed)
Flight Capacity	5 passengers	--Not Listed--	18 people or payloads up to 5 tons
Cruising Speed	Avg: 135 mph	--Not Listed--	230 mph
Notes	Hybrid-Electric Retrofit of Cessna 337 (Skymaster)	Hybrid-Electric retrofit of De Havilland Canada Dash 8 Expected in 2024	Bio-Electric Hybrid Expected in 2026 (All-Electric version in 2030)
	Wright Electric/Easyjet Wright Spirit 	**Wright Electric** Wright 1 	**Eviation** Alice 
Range	1 hour	800 miles	500 miles
Flight Capacity	100 people	186 people	9 Pax (+2 crew)
Cruising Speed	--Not Listed--	--Not Listed--	Max 288 mph
Notes	Targeted for 2026 Retrofits BAe 146 regional airliner	Targeted for 2030 20 MW	Purchase Price: $4 million Operating Costs: $200/flight hr Taking reservations for 2026 release date

Outdoor Recreation

Electric Snowmobiles

Cold weather transportation is a sector that has not regularly been in the spotlight of renewable energy, but it is in desperate need of clean solutions. This rapidly improving technology has many benefits over its gas counterparts. Gas-powered snowmobiles have little to no emissions standards and many have two stroke engines causing them to be sometimes as much as 50 times more polluting than the average car.[1] Less emissions and pollution is an obvious plus, but financially these machines also have the huge advantage of needing practically no maintenance, which reduces cost of ownership. There is no fuel, no oil, no transmission, and no drive belts, so the cost of operation is much lower and that means more time can be spent out riding rather than doing costly fixes back at home. These snowmobiles are compatible with and can charge anywhere with automotive standard equipment. The average charging time with the AC 240V Level 2 charger is about 2 hours, but now there exists a DC fast charger which can bring the battery up to 80% in just 20 minutes.[45]

	Taiga Motors Ekko Mountain 	**Taiga Motors** Atlas Crossover 	**Taiga Motors** Nomad Utility 
Range	60-80 miles	64-87 miles	62-83 miles
0-60mi/h	3.3s	2.9s	--Not Listed--
Towing	--Not Listed--	--Not Listed--	1,126 lbs
Engine Package	180 hp	180 hp	120 hp
Battery	27 kWh	27 kWh	27 kWh
Charging Time	3.5 hours	3.5 hours	Level 2: 3.5 hours Level 3: 80% in 30 mins
Cost	Starting at $17,490	Starting at $17,490	Starting at $17,490
Weight (ride ready)	586 lbs	597lbs	607lbs
Track	165”x 15”x 2.5”	137”x15”x1.6”	Studded 154”x16”x1.6”
Front Suspension	Double wishbone Travel: 220mm / 8.66”	Double wishbone Travel: 220mm / 9.05”	Double wishbone Travel: 224mm / 8.82”
Rear Suspension	Rad-M multilink Travel: 270mm / 10.6”	Rad-X multilink Travel: 300mm / 11.8”	Rad-u multilink Travel: 300mm / 11.8”
Stance	950mm / 37.4in	1074mm / 42.3in	074mm / 42.3in
Dimensions	Height: 1482mm / 58.2in Length: 3360mm / 132.3in	Height: 1278mm / 50.3in Length: 3158mm / 124.3in	Height: 1550mm / 61.0in Length: 3275mm / 128.9in
Features	HD display with GPS mapping Custom terrain profiles Powder flow package	HD display with GPS mapping Custom terrain profiles Click adjustable shocks	HD display with GPS mapping 2-up seating Active stability management

Electric Golf Carts

	EVolution Carrier 6 Plus 	**Moto Electric Vehicles** MotoEV 6 ENB-6PFF 	**Moto Electric Vehicles** MotoEV 4 Passenger Wheelchair Golf Cart 	**Bintelli Electric Vehicles** Bintelli Beyond 6PR 
Range	40 miles or 17 hours per charge	50 miles	50 miles	35 miles
Speed	Up to 25 mph	Up to 25 mph	Up to 25 mph	Up to 25 mph
Capacity	6 people	6 people	4 people + 1 wheelchair	6 people
Cost	$13,250	$13,995	$19,995	$11,995
Other Features	Option to register as street legal 9in touchscreen display with speedometer, back-up camera, Bluetooth and more	Option to register as street legal Option to add a 110W solar panel to roof for $1,995	Equipped with Q'Straint tie downs and buckles for securing wheelchair Option to add a 110W solar panel to roof for $1,995	Option to register as street legal Bluetooth, back-up camera
	Club Car V4L 	**ICON Electric Vehicles** i40L 	**E-Z-GO** Freedom RXV 	**E-Z-GO** Valor 
Range	--Not Listed--	25-50 miles	--Not Listed--	--Not Listed--
Speed	Up to 19 mph	Up to 25 mph	Up to 19 mph	Up to 19 mph
Capacity	4 people	4 people	2 people	2 people
Cost	$9,750	$10,495	$12,499	$8,499
Other Features	Almost all Club Car® vehicles have the option of being electric	2, 6 and 8 seat versions also available	56V ELiTE Lithium battery	(4) 12V deep cycle batteries

Other Low Speed Electric Vehicles

	GEM e6 	**GEM eL XD** 	**The Pickman Classic** 	**The Pickman XR** 
Range	~67 miles	~67 miles	~50 mile range	70-90 miles
Speed	Up to 25 mph	Up to 25 mph	Up to 25 mph	Up to 50 mph
Capacity	1-6 people	1-2 people	1-2 people	1-2 people
Cost	Starting at $19,113	Starting at $16,731	Starting at $13,500	$25,000 - $29,000
Other Features	--Not Listed--	Payload: up to 1,400 lbs Towing: up to 1,250 lbs	Towing: up to 4,000 lbs	Towing: up to 6,000 lbs

Electric All-Terrain and Utility Task Vehicles

	Eco-Rider Explorer GT 	**DRR** EV Stealth 	**DRR** EV Safari 4×4 	**Polaris** Ranger EV 
Range	25-30 miles	35 miles	35 miles	35-45 miles
Speed	31 mph	25 mph	45 mph	25 mph
Capacity	Payload: 330 lbs Towing: 880 lbs	Payload: 450 lbs	Payload: 450 lbs Towing: 800 lbs	Payload: 1,000 lbs Towing: 1,500 lbs
Cost	~$6,000 USD	$9,299	$14,999	$14,699
Other Features	Lead Acid Battery Available with Lithium Ion for ~$8,500	Silent 4 kW motor	Silent 7.5 kW motor	Seats up to 2 people Lead Acid Battery 30 hp
	Tracker Off Road EV iS 	**Tracker Off Road** OX EV 	**ZeroNox** Tuatara 1500E 	**Volcon** Stag 
Range	16 miles	36-60 miles	30-50 miles	100+ miles
Speed	Up to 24.5 mph	Up to 16.5 mph	Up to 27 mph	Up to 80 mph
Capacity	Payload: 840 lbs Towing: 1000 lbs	Payload: 900 lbs Towing: 1,200 lbs Dump Bed: 500 lbs	Towing: 2,200 lbs Dump Bed: 1,200 lbs Winch Pulling: 4,500 lbs	Payload: 1,550 lbs Towing: 2,000 lbs
Cost	$13,999	$12,999	$35,000	Starting at $39,999
Other Features	Seats up to 4 people (6) 12V Heavy-Duty Deep Cycle Batteries 38 hp	Seats up to 2 people Gen 2 Samsung Lithium Battery	Seats up to 3 people Lithium Iron Phosphate Battery Charge Time: 3.5 hours	Seats up to 4 people 125 or 140 hp 42 kWh battery
	Daymak **Boomerbeast 2D** 	**Daymak** **Boomerbeast 2D Deluxe** 	**Daymak** **Beast ATV Deluxe** 	**Daymak** **Dune Buggy 3000** 
Range	Up to 31 miles	Up to 62 miles	Up to 50 miles	Up to 25 miles
Speed	Up to 31 mph	Up to 31 mph	Up to 31 mph	Up to 25 mph
Battery	60V 32Ah Lead Acid	60V 56Ah Lithium Ion	60V 50AH Battery Pack	60V 50AH Lead Acid
Charge Time	6-8 hours	6-8 hours	8-10 hours	10-12 hours
Climbing Incline	30 degrees	30 degrees	25 degrees	30 degrees
Cost	$5,699	$6,999	$7,799	$7,999

Electric Fishing Boats

	Freedom Electric Marine Twin Troller X10 	**Veer** V13 	**Electric Boats** 6M Electric Al Capone 	**Rock Proof/Elco** ePro 1760R 
Description	"Our in-hull, dual electric motor drive system allows for better boat control, giving you a faster response time to wind and waves as you navigate the water. Our goal is to make sure you're able to fish wherever, whenever you want—and the Twin Troller x10 does just that."[46]	"This shallow-draft fishing boat is built from durable rotomolded polyethylene to get you where others can't go. The lightweight design makes it easy to trailer behind a car or small SUV, and with easy-to-drive operation, adventure can be as spontaneous as you want it to be."[47]	"It has a 120kW motor hooked up to a standard Mercruiser SE116 outdrive – and delivers a top speed of 30 knots (55 km/h) and cruising speed of 16 knots (30 km/h). Kelly designed the Capone so that it can be charged using a regular plug at home, using about $4 NZ of electricity. That's about $2.65 USD"[48]	"The boat features an integrated 18-gallon live well and factory-installed options include trolling motors, power poles, jack plates, locking or open rod storage and a custom aluminum trailer."[49]
Range	--Not Listed--	Full throttle: 1hr/5mi 25% throttle: 19hr/34mi	Up to 50 hours	13.5-19 miles
Length	10 ft	13 ft	19 ft	17 ft
Capacity	Up to 3 people	Up to 2 people	--Not Listed--	Up to 2 people
Cost	$4,795	$14,095	--Not Listed--	$62,550
Notes	Hands free, foot pedal controls Fits in the bed of a standard pickup truck Battery not included	7.5e Mercury Avator™ electric outboard package 1 kWh Lithium Ion Battery	150 hp Aluminum Speed: Up to 30 knots	115 hp 20-40 kWh battery options

Electric Outboards

Seaweed farming off the coasts of Zanzibar has been an essential industry for decades. The farmers, primarily women supporting their families, used to be able to collect seaweed just by wading into the shallow waters near shore. However, due to climate change, those waters have become too warm and seaweed is now grown in deeper, colder waters that require a boat to access.

Recognizing this issue, The Ministry of Agriculture and Fisheries introduced a program to have 500 fiberglass boats locally built. Unfortunately, their two stroke motors have been difficult to start and require a male operator to accompany the women. They are also expensive to fuel. Gasoline to run the boat each day costs about 7 USD. For a country whose average income is about 4 USD/day, even splitting the fuel costs between several people is a substantial burden.

But electric outboards are about to change all of this! With just the push of a button, the women can start the engines on their own (Figure 10) and no longer require an escort. To address the cost of recharging the batteries, they're also adding 600W solar panel roofs that provide shade on the boat and provide local jobs to build and install.

Figure 10: Taking a test drive with ePropulsion.

Switching to an electric motor like ePropulsion's Navy 6.0 Evo, will also prevent pollution. One expert calculated that switching Zanzibar's fleet to electric will prevent 115 metric tonnes of two-stroke oil and 1,625 metric tonnes of gasoline from entering the sea over a 10-year period. It will also prevent 11,000 metric tons of CO_2 from entering the atmosphere.[50]

	ePropulsion Spirit 1.0 Plus Electric Outboard Motor	**ePropulsion** Navy 6.0 Evo Electric Outboard Motor	**ePropulsion** H-100 Electric Inboard Motor
			
Range	7.8-80 miles 36 hours at 35W 1.25 hours at 1000W	22.5-72 miles 18 hours at 500W 1.5 hours at 6000W	Powers vessels between 60 to 100 ft
Speed	2.2-6.2 mph	4-15 mph	
Power	35-1000W	500-6000W	1000 kW

Electric Yachts

Silent-Yachts offers several models of luxury electric yachts (Figure 11). With large arrays of solar panels, these models have ocean crossing capabilities and potentially unlimited range. Silent-Yachts provides an 8-year warranty on their batteries, a 25-year warranty on their solar panels, and a lifetime warranty on their electric motors.[51]

Figure 11: A quick look inside the Silent 120 Explorer

	Silent-Yachts Silent 60	**Silent-Yachts** Silent 80	**Silent-Yachts** Silent 120 Explorer
			
Length	59 ft	79.8 ft	120 ft
Beam	29.5 ft	35.8 ft	45.4 ft
Solar Power Generation	Peak: 16 kW	Peak: 26 kW	Peak: 40 kW
Battery	143, 207, or 286 kWh	200, 286 or 429 kWh	Up to 800 kWh
Cruising Speed	6-8 knots	6-8 knots	10 knots
Top Speed	13-20 knots	18-19 knots	14-16 knots

Electric Speedboats

	Silent-Yachts Silent 28	**Blue Innovations Group** R30	**Soel Yachts** Electric Speedboat (Custom)
			
Length	28.2 ft	30 ft	32.8 ft
Solar Power Generation	Peak: 704 W	2.7 kW	--Not Listed--
Battery	99 kWh	221 kWh	71 kWh
Top Speed	60+ knots	39 knots	30 knots
Capacity	10 people	12 people	--Not Listed--
Range	70+ nm	8 hours	--Not Listed--

Electric Inflatable Boats

Don't want to deal with a hauling your boat in a trailer? The Electricat by Hovercraft d.o.o deflates and folds up small enough to fit in the back of most vehicles (Figure 12). These unique boats are not only inflatable for more convenient transporting and storing, they also include rooftop solar panels to supplement their battery power.

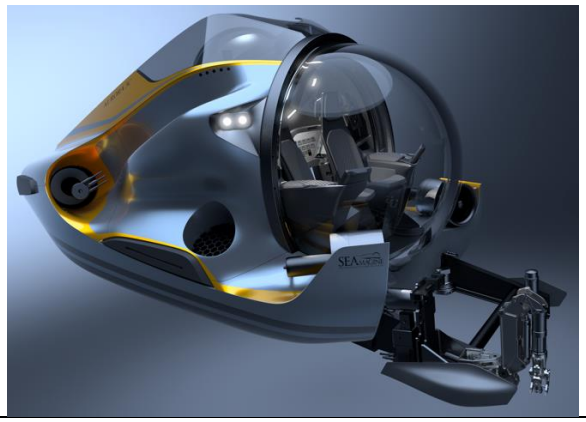
Figure 12: Folded size of 4.9ft x 3.3ft x 1.6 ft

Figure 13: Curtains for sun protection and privacy

Advertised as "the sun-powered, fun-powered inflatable houseboat!"[52] the Electricat 600 Big Six can comfortably sleep 6 people (Figure 13).

	Hovercraft d.o.o. Electricat 450	**Hovercraft d.o.o.** Electricat 600 Big Six
		
Length	14.8 ft (4.5m)	19.7 ft (6m)
Inflation Time	5 min to 1 hour	5 min to 1 hour
Speed	3 knots with solar, 6 knots with battery	3 knots with solar, 6 knots with battery
Range	31 miles	31 miles

Electric Submarines and Submersibles

	Triton Deepview 24 	**SeaMagine** Aurora-3C Model 
Description	"With a Triton DeepView cruise lines and tourist operators can provide clients with an unforgettable adventure in a cost-efficient and easily maintained package."[53]	"With a diving depth of 460m or 1000m, this model is ideal for fitting on ships with tight storage space and does not require a large launch recovery system."[54]
Length	50.5 ft	13.8 ft
Submersion Depth	328 ft (100m)	1500 ft (460m) or 3280 ft (1000m)
Battery	240 kWh	30 kWh or 40 kWh Pressure Balanced Lithium Ion
Capacity	2 pilots + 24 passengers	1 pilot + 2 passengers
Speed	3 knots	3 knots
Range	14 hours	14 hours
	U-Boat Worx Nemo 2 	**SeaMagine** Aurora-100 Series 
Description	"Alongside a qualified NEMO pilot, anyone can take supervised control of the NEMO 2 thanks to our unique MANTA Controller whereby you can easily hand over steering control to your fellow explorer."[55]	"The Aurora-100 Series features an ultra-large acrylic cabin that can be configured either for spacious seating or for extra deep diving."[56]
Length	9.2 ft	16.7 to 18 ft
Submersion Depth	328 ft (100m)	328 ft (100m) to 7545 ft (2300m) (depending on configuration)
Battery		30 kWh or 45 kWh Pressure Balanced Lithium Ion
Capacity	1 pilot + 1 passenger	1 pilot + 2-6 passengers (depending on configuration)
Speed	3 knots	3 knots
Range	8 hours	14 hours

Electric Personal Watercraft

	Taiga Orca	**Narke** GT95
		
Description	"Orca reinvents on-water powersports. Direct electric drive and unique hull shape deliver all-out control that cuts through water with agility and grace for a wholly new riding experience. Orca elegantly combines the performance-focused electric powertrain with near-non-existent throttle lag and bespoke design for outright fun and sustainable waterway adventure."[57]	"Narke's latest electric jet ski picks up where the first-generation GT45 left off, with more power, range, and a cutting edge design… The hull utilizes deflection technology to make the ride stable and smooth for operators of nearly any skill level. A seven-inch customizable digital display displays the remaining charge, mileage, distance from port, and can take incoming calls — if you're brave enough to bring your phone."[58]
Seats	Seating for 2	Seating for 3
Range	~28 miles	~31 miles or 2 hours of riding
Speed	Up to 65 mph	Up to 47 mph
Power	120 kW / 160 hp	71 kW / 95 hp
Battery Capacity	24 kWh	24 kWh
Charging Time	3.5 hours	1.5 hours
Cost	Starting at $17,490	$47,000

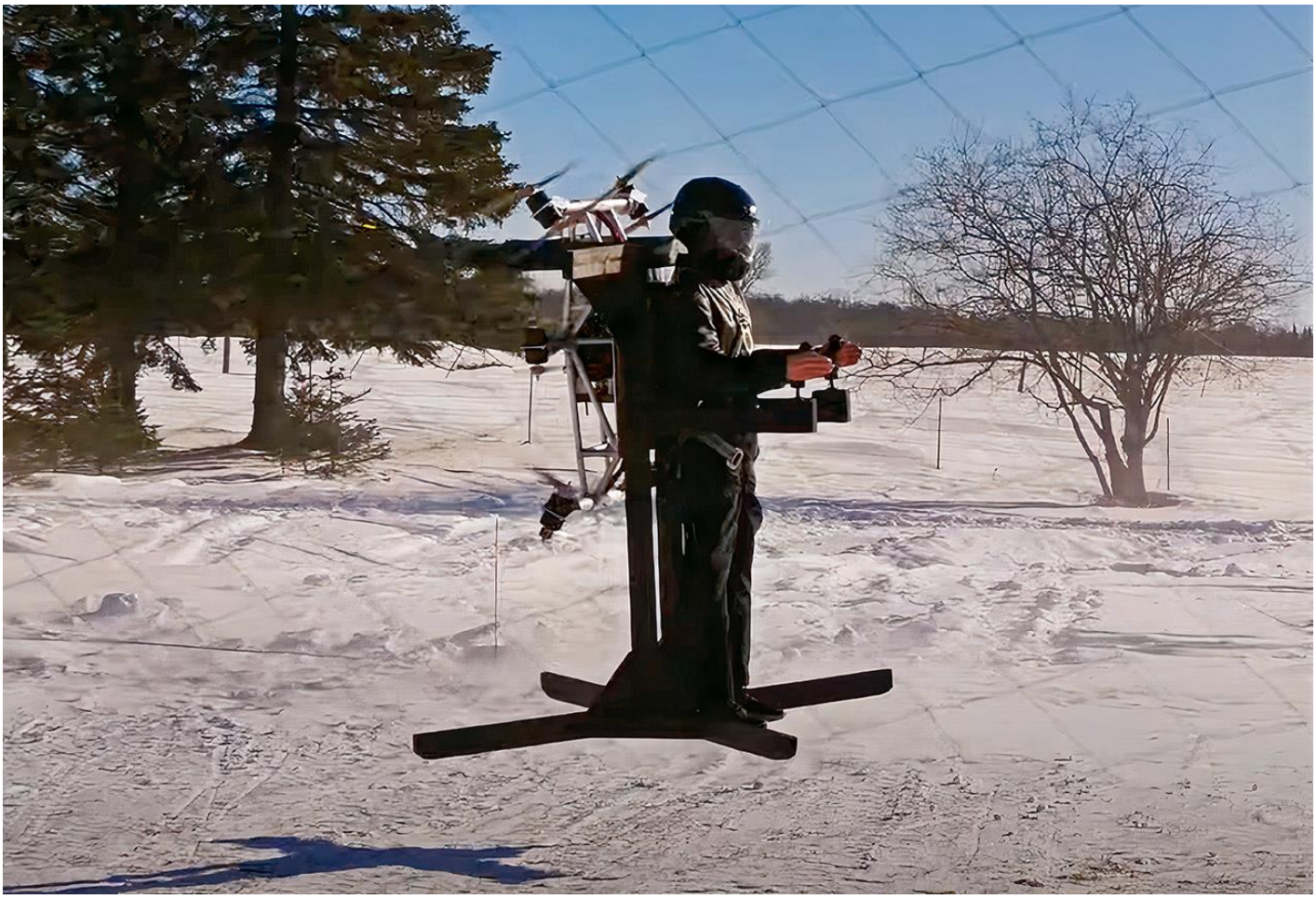


Figure 14: Ascend Dynamics' SkyPack V1 Jetpack uses six pairs of counter-rotating propellers run by (12) 7 kW brushless DC motors. As of 2022, the first prototype could fly for 2 minutes when fully charged. The next model, V2, is supposed to increase the payload from 170 pounds to 200 pounds.[59]

Figure 15: Electric Jet Aircraft's EJ-1H Jetpack uses six battery powered ducted fans to provide more than 320 lbs of thrust to carry a 200 pound pilot. The EJ-1 has gone through several variations and proof-of-concepts since 2019. Electric Jet Aircraft hopes their jetpack will be used for anything from air shows and personal use to first responders.[60]

Construction and Farming

Electric and Hybrid Construction Equipment

Redwood Energy has provided a list of electric construction products that can help meet California Environmental Quality Act (CEQA), and other states' guidelines for construction. Using electric equipment can greatly reduce the noise and emissions from the construction process. As a disclaimer, this guide is not an exhaustive list of all electric equipment available and contact should be made with manufacturers, distributors, and rental companies to determine availability of each product, current prices, and if the product specifications have changed.

Figure 16: Various benefits of going all-electric.

Air pollution from diesel construction equipment, such as excavators, skid steers, and bulldozers, causes health risks and is subject to strong environmental regulation, particularly in California under the California Environmental Quality Act (CEQA). The combustion emissions from heavy equipment include nitrogen oxides, reactive organic gases, greenhouse gases, and diesel particulate matter. Depending on the size and location of the project, mitigation for these emissions may be required under CEQA and other state regulations.

Mitigation measures, such as installing diesel emission control devices, limiting idling time, reducing construction periods,[26] and phasing equipment use times can all contribute to the expense and time required for a project.[28] If mitigation measures are not adopted, an offsite mitigation fee may be required to be paid. For example, the Sacramento Air Quality Management District sets a rate of $30,000 per ton of emissions.[28] By electrifying equipment, combustion emissions are eliminated, and regulatory compliance costs and difficulties are reduced.

Table 2-4
Thresholds of Significance for Construction-Related Criteria Air Pollutants and Precursors

Pollutant/Precursor	Daily Average Emissions (lb/day)
ROG	54
NO_X	54
PM_{10}	82*
$PM_{2.5}$	54*

* Applies to construction exhaust emissions only.
Notes: CO = carbon monoxide; lb/day = pounds per day; NO_X = oxides of nitrogen; $PM_{2.5}$ = fine particulate matter with an aerodynamic resistance diameter of 2.5 micrometers or less; PM_{10} = respirable particulate matter with an aerodynamic resistance diameter of 10 micrometers or less; ROG = reactive organic gases; SO_2 = sulfur dioxide.
Refer to Appendix D for support documentation.

Figure 17: Significance thresholds adapted from Bay Area Air Quality Management District

In addition to regulating air pollution emissions, CEQA requires strict noise pollution guidelines. Typical diesel excavators emit noise pollution upwards of about 81-85 dBA, and typical Backhoes emit about 78-80 dBA.[61] At 50 feet, this is often outside the typical acceptable thresholds for the construction noise generated by a project under CEQA review. For instance, in the City of Los Angeles, the conditionally acceptable Community Noise Exposure Levels range from 55 to 70 decibels, depending on zoning.[62]

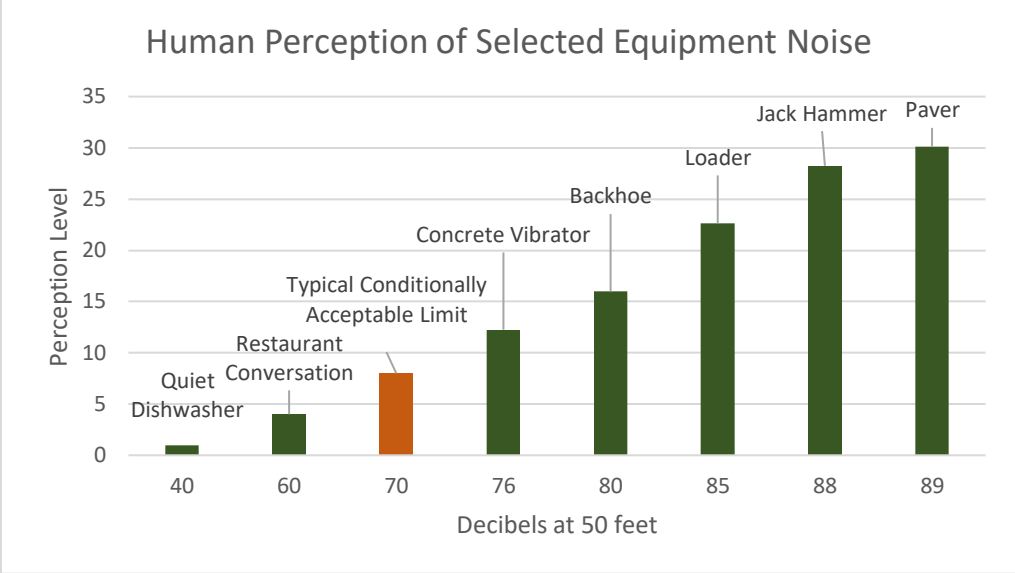


Figure 18: An increase of 10 decibels is generally perceived by humans as a sound becoming twice as loud. From a 40dB standard, common construction equipment was modeled to fit the perception curve. (Redwood Energy)

Construction noise impacts can require mitigation to receive project approval from the jurisdiction under CEQA. These mitigations can force managers to employ alternative construction methods, create detours and haul routes, and deploy noise walls, creating additional costs and delays for projects.

Figure 19: Bucyrus-Erie model 1850-B, AKA "Big Brutus", the largest existing electric shovel in the world.

New electric construction equipment from tried and true manufacturers should be considered a form of mitigation measure. Because these products can significantly reduce community noise exposure, zero out tailpipe emissions, and since construction managers must make a conscious effort to employ these products, they represent a mitigation of typical diesel equipment noise impacts. Many jurisdictions already consider a product with a quieter design to be a mitigation.

Growing interest in the rental market for fully electric equipment has led to a surge in new designs in the past 5 years. This has meant that options from well-established manufacturers are being released at warp speed. The reduction in fuel and maintenance costs are appealing to rental companies and construction firms alike. When considering the costs savings and the avoided costs of pollution permits, it just makes financial sense to switch to using electric products wherever possible.

Electric Backhoes and Excavators

	Volvo ECR25 Electric Excavator 	**Komatsu** PC30E-5 Electric Excavator 	**JCB** 19C-1E 
Description	The Volvo ECR25 Electric replaces a combustion engine with 48-volt lithium-ion batteries and an electric motor that powers the hydraulics to move the machine and attachments. The batteries store enough energy to power the machine for 8 hours in typical applications, such as utility work.[63]	"Equipped with an in-house developed new charger, high-voltage converter and other devices, it offers excavation performance on par with the internal combustion model of the same power output, while achieving zero exhaust gas emissions and a dynamic reduction in noise levels." [64]	"The 19C-1 E-Tec will feature the same speed and power as its diesel counterpart, the 19C-1, but with the added benefit of generating greater torque which it can do instantly. The electric motor will also power the load-sensing hydraulic system from Bosch Rexroth."[65]
Battery Capacity	20 kWh	36 kWh	15 kWh – 20 kWh
Max Power	18 kW	18.2 kW	20 kW
Noise Level	74 dB (operator) - 84 dB (around machine)	--Not Listed--	10 dB quieter than diesel equivalents
Operating Time	4 hours	8 hours with charging during breaks	5 hours
Other Specs	Fast charging: 80% in 50 minutes 48V Batteries	Two charging options available: 1) Standard full charge 2) Rapid charge up to 80% capacity	80% battery capacity after 10 years (3000 cycles)
Cost	$92,900	--Not Listed--	~$50,000

	Bobcat E10e Mini Excavator 	**Bobcat** E19e Mini Excavator 	**Bobcat** E32e Mini Excavator 
Description	"With a light and compact zero tail swing design, near-silent operation and zero emissions, Bobcat says the E10e was built for indoor use. Bobcat says the E10e provides the same "or even better" performance as its diesel counterpart the E10z, and it can be operated with all E10z attachments." [66]	"The E19e has impressive torque in a compact package with a retractable undercarriage and blade. An on-board charger supports 12-hour overnight charging."[67]	"The battery-powered E32e delivers near-instantaneous full torque, which creates loads of hydraulic power and delivers smooth control."[67]
Battery Capacity	11.5 kWh	17.3 kWh	44.5 kWh
Max Power	7.5 kW	10 kW	12.4 kW
Noise Level	74 dB(A) - 84 dB(A)	--Not Listed--	--Not Listed--
Operating Time	8 hours with charging during breaks	4 hours of continuous operation	4 hours of continuous operation
Other Specs	Half the noise of diesel competitors[68]	--Not Listed--	--Not Listed--
Cost	--Not Listed--	Available in Q2 2023	Available in Q2 2023

	Pon Equipment Cat 323F Z-line Excavator 	**Hyundai CE/Cummins** R35E 	**Wacker Neuson** EZ17e Compact Excavator 
Description	"We do not want to invent a new excavator. Cat® 323F is one of the world's best excavators. We only want it in an emissions-free version, with the same performance as the diesel-powered." [69]	"This electric powered mini excavator is an exciting celebration of the future of electrified construction equipment – combining the strengths of HCE's versatile excavator with Cummins' lithium ion battery solutions and machine integration expertise."[70]	"It's aimed for urban work, tunnels, inside buildings, golf courses, schools, hospitals and other construction jobs where you want to keep emissions and noise to a minimum." [71]
Battery Capacity	300 kWh	35 kWh	23.4 kWh
Max Power	122 kW	14.6 kW (19.6 hp)	16.5 kW
Noise Level	--Not Listed--	--Not Listed--	"10-times quieter than a conventional compact excavator"[72]
Operating Time	5 – 7 hours	8 hours	7 hours
Other Specs	3.4-ton battery pack	3.5-ton size class, charges in 3 hours	Charging by domestic 110V socket, or 230V
Cost	$650,000	--Not Listed--	--Not Listed--
Notes	--Product currently available only in Europe--	--Not Listed--	--Expected to be available in North America in late 2023--

	Case 580EV Electric Backhoe Loader	**John Deere** 310 X-Tier Electric Backhoe	**CASE** CX15EV
			
Description	"The CASE 580 EV (electric vehicle) delivers backhoe power and performance equivalent to its diesel counterpart while also providing instant torque, lower jobsite noise, lower daily and lifetime operating costs, reduced maintenance demands and absolutely zero emissions."[73]	"The 310 X-Tier E-Power electric backhoe can do everything the diesel backhoe can do, but better –John Deere says it has 10-15% more performance."[74]	"The 1.5 metric ton CX15 EV is a dynamic electric mini excavator that is easy to transport, fits through almost every entryway for work indoors or outdoors, and features the same working performance as a diesel machine."[75]
Battery Capacity	90 kWh	--Not Listed--	21.5 kWh
Max Power	--Not Listed--	--Not Listed--	16 kW
Noise Level	--Not Listed--	Less than 75 dB	72 dB(A)
Operating Time	8 hours	8-12 hours	8 hour workday
Other Specs	3-phase power charging (fast charging)	Still in prototype stage	Charge time: 80% in 1 hour
Cost	90% lower operation cost	--Not Listed--	--Not Listed--
Notes	--Not Listed--	--Not Listed--	--Not Listed--

Electric Compact Loaders

	First Green Industries Elise 900	**Volvo** L25 Wheel Loader	**Wacker-Neuson** WL20e	**Gehl** Skid Steer 165e
				
Description	"The Elise 900 loader is a good assistant for loading, lumping or relocating rocks of classes 1 to 4, all with a basic shovel. Specially designed attachments make it possible to use it also for mining of rocks, digging of narrow grooves or drilling of holes in rocks of 1st and 2nd class."[76]	"The L25 Electric is powered by lithium-ion batteries that cover an eight-hour working shift with one single charge in the machine's regular applications, which include light infrastructure work, gardening, landscaping, and agriculture...it feels similar when it comes to power but is quieter, has less vibration, less maintenance, and is emission-free locally."[77]	"Two electric engines, one for the drive system and one for the work hydraulics, ensure that the performance features of the WL20e correspond to those of the conventional machine. At the same time, the wheel loader works completely exhaust free and with significantly lower noise emissions."[78]	"It can also operate in the same outdoor environments, but because of its quiet operation and zero emissions, it could also be used for indoor demolition and work near hospitals, schools and other noise- and pollution-sensitive environments."[79]
Battery Capacity	23 kWh-39kWh	40 kWh	11 – 15 kWh	--Not Listed--
Max Power	10 kW	22 kW	9 kW	"Based on 69-hp skid steer"[79]
Operating Time	6-8 hours	8 hours	5 hours	8 hours
Other Specs	11-ft boom attachment height Climb grades up to 35°	48-volt battery modules	Estimated operating cost savings 40%	1,650 pound load capacity 48-volt battery modules

	Bobcat T7X Compact Track Loader	**Bobcat** S7X Skid Steer Loader	**XCMG** XC918-EV	**LiuGong** 856H-E MAX Wheel Loader
				
Description	"The award-winning Bobcat T7X is the world's first all-electric compact track loader. Completely battery powered, this machine is the first of its kind to eliminate all hydraulic components and emissions. With all the performance found in its diesel counterparts and more, the T7X can generate incredible performance characteristics with instantaneous torque that's as much as three times greater than traditional loaders."[67]	"As the inventor of the original skid-steer loader, Bobcat is proud to reinvent the machine that created the industry with the introduction of the S7X all-electric skid-steer loader. The S7X produces zero emissions as it features a redesigned drivetrain that is fully powered by its innovative 60.5-kWh lithium-ion battery."[67]	"XCMG 2 ton electric mini wheel loader XC918-EV replaces "diesel oil" with "electricity". The traveling system and hydraulic system are controlled by electric motors, pure electric and zero emissions, saving air filter, machine filter, oil filter and other maintenance costs and energy consumption. The cost is only 1/3 of that of a diesel loader, which is economical and efficient."[80]	"The 856H-E MAX features intelligent controls and a human-centric design for a superior operator experience. This includes load-sensing hydraulics, an EAT700 transmission with an electro-proportional valve for fast, smooth shifting, and independent control of the dual-motor drive for maximum hydraulic lift."[81]
Battery Capacity	60.5 kWh	60.5 kWh	100.3 kWh	423 kWh
Max Power	80 kW	80 kW	64 kW	160 kW
Operating Time	8 hours	8 hours	Up to 8 hours	8-10 hours
Other Specs	Tipping Load: 8429 lbs	--Not Listed--	Operating Load: ~4,000 lbs	Tipping Load: 38,360 lbs

Electric Heated Screeds for Pavers

	LeeBoy 8515E Legend Electric Screed System 	**Cat** SE50 V Vibratory Screed 	**Mauldin** Silver 16 Screed 
Description	"The Legend Electric Screed System, powered by an on-board generator, offers the safety benefit of no flame, fuel or fumes from the screed heating process, along with consistent temperature control of the heating elements across the width of the screed plate and screed extensions."[82]	"The 70 kW, tractor integrated generator combined with the technologically advanced screed heating system, ensures fast, even heat distribution. The 15 minute heating time at standard widths can lead to more daily production and lower fuel consumption due to less time waiting for the screed plates to reach the preset temperature. At maximum widths screed plate heating occurs in as little as 25 minutes."[83]	"The electrical heating system allows independent zone temperature control, and the 10 kW hydraulically powered generator delivers enough power to heat the screed even with paver engine running at idle."[84]
Max Power	10kW electric generator	--Not Listed--	10 kW
Paving Width	8' to 15'	8' 4" to 16' 4"	15.5'
Weight	17,600 lbs	7,239 lbs	--Not Listed--

Hybrid and Dual Power Options

	Caterpillar D7E 	**Wacker-Neuson** 803 Dual Power Excavator 
Description	"Since the introduction of the D7E dozer, customers worldwide have saved millions of liters/gallons of diesel fuel and reduced overall emissions. The diesel-electric power train gives you the power you need for dozing while using significantly less fuel."[85]	Compact diesel excavator with optional electric power hydraulic motor system that can be plugged into the grid. Allows the excavator to be run completely emissions-free while powered by that motor.
Description	Diesel-Electric Hybrid	480V 3-phase hydraulic motor
Max Power	178 kW	15hp diesel, 10hp electric
Noise Level	110 dB, 73 dB in cab	93 dBA (diesel mode)
Fuel Capacity	108 gallon tank	1.8 gallons
Battery Capacity	8 kWh	--Not Listed--
Other Specs	U.S. EPA Tier 4	39.4 ft hydraulic hose length for electric drive.

Electric Forklifts

	Cat EP55NH	**Toyota** 80V Electric Pneumatic	**Hyster** J80-120XN	**Yale** ERC120VH
				
Description	"Designed to handle intensive applications and harsh environments, where you would normally expect to use IC engine machines, these powerful high capacity electric forklift trucks offer a clean and extremely efficient alternative."[86]	"These electric powerhouses combine the power, durability, and reliability of internal combustion trucks with the ergonomics and speed of electric forklifts. With a capacity ranging from 5,000-17,500 lb., these machines are ready to tackle any challenge."[87]	"Continuing to bridge the gap between outdoor internal combustion engine (ICE) applications and indoor electric applications, the J80-120XN provides an environmentally friendly option for industries that have historically been ICE applications."[88]	"The ERC-VH series is your electric solution for heavy lifting. It offers the power of an ICE but the efficiency of an electric, with the ergonomics and toughness to handle the heaviest loads, all shift long."[89]
Capacity	12,000 lbs	4,000 – 17,500lbs	8,800 – 12,000 lbs	12,000 lbs
Voltage	80V	80V	80V	80V
Motor Power	34 kW (hoist) (2) 16 kW (traction)	16.7-32 kW (load handling)	36 kW (pump motor) (2) 14.7 kW (traction)	36 kW (pump motor) 21 kW (traction)
Sound Level	--Not Listed--	--Not Listed--	68 dB(A)	66 dB(A)
	Hoist FR-E Series	**Toyota** High Capacity Electric Cushion Forklift	**Linde** E180	**Crown** FC Series
				
Description	"The innovative extendable counterweight frame is designed to provide stability at full capacity and extended load centers, yet is compact enough for maneuvering in confined areas."	"The versatile electric power and high visibility combined with a large 92-inch wheelbase means you'll have the power you want and the maneuverability you need for your heaviest indoor duties."[90]	"A quick battery change is possible for 24/7 use. Thanks to the powerful electric motors, the new heavy trucks are in no way inferior to Linde's most powerful IC truck to date, putting them at the top of the performance range."[91]	"Dual drive motors turning in opposite directions, along with steer axle geometry designed for maneuverability, enable the FC Series sit-down counterbalance forklift to navigate tight turns in small spaces."[92]
Capacity	15,000 – 80,00 lbs	15,000 – 40,000 lbs	40,000 lbs	6,500 lbs
Voltage	72/80V	72/80V	80V	36/48V
Motor Power	--Not Listed--	24 kW (pump motor) 31.7 kW (traction)	(4) 18 kW	11.4 kW (lift) (2) 7.9 kW (traction)
Sound Level	--Not Listed--	--Not Listed--	70 dB(A)	--Not Listed--

Electric Tractors

Carlo Mondavi, grandson of the famous Napa Valley winemaker Robert Mondavi, is looking to change the agricultural industry and reduce its carbon footprint. Along with practicing regenerative agriculture and increasing biodiversity, Mondavi is also reducing his dependence on fossil fuels and leaning into renewable energy sources. As part of this effort, Mondavi helped spearhead Monarch's all electric MK-V Tractor (featured in the product guide below). Not only is the MK-V electric, it can even work autonomously and gathers crop data to help farmers operate more efficiently (Figure 20). Some skeptics argue there are larger environmental issues related to agriculture, like monocultures and the global supply chain. However, Mondavi sees this as an opportunity for organic farming and also points out just how much more polluting a tractor is than a regular vehicle. Mondavi says there's been pushback on organic farming because it requires more tractor use and thus creates a new set of environmental concerns. By replacing diesel tractors with electric, this eliminates a major complaint and can promote more organic farms.[93]

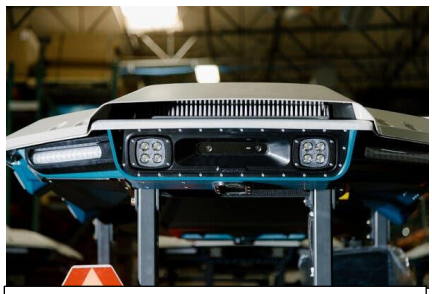


Figure 20: Cameras and sensors in the roof help gather data.

	John Deere GridCON	**Solectrac** e70N Electric Tractor	**Fendt** e100 Vario	**Monarch** MK-V Tractor
				
Description	"This autonomous concept is based on a John Deere 6210R tractor chassis. GridCON uses a cable connection from a stationary power supply at the field to the tractor. There is a continuous 300KW power supply through the cable in which a 100 kW electric motor feeds an IVT transmission."[94]	"The 70 HP Category e70N is a powerful, narrow electric tractor that is perfectly suited for vineyards and orchards."[95]	"The Fendt e100 is not just an idea, but a specific project designed to make sustainable improvements to your work in future…This future-oriented and economical tractor not only reduces energy costs, but also maintenance and service costs."[96]	"With exportable power, the MK-V electric tractor becomes a portable generator—providing you with power in every block on your farm. Power your harvest lights and converse without shouting or weld a broken gate or fence out in the field. With Monarch, clean, quiet power is wherever your tires can take you."[97]
Power	300 kW supply through cable	41 kW	50 kW	52 kW
Battery Runtime	--Not Listed--	3-8 hours	5 hours	14 hours
Battery Capacity	--Not Listed--	60 kWh	100 kWh	--Not Listed--
Price	Still in prototype	$75,000	--Not Listed--	$68,000

	SABI-AGRI POM – The Modular Tool Holder 	**SABI-AGRI** ALPO – Electric Straddle Tractor 	**Amos Power** Autonomous Tractor 
Description	"Its driving position offers unparalleled visibility of the tools and work areas. Its unique mechatronic architecture makes it exceptionally energy efficient, with 10 times less energy consumed and low maintenance. With its light weight, it preserves the soil even for operations requiring repeated passes or in case of intervention after a rain."[98]	"Combines the working power of a thermal tractor with the advantages of electric power**.** Its 3 work zones are compatible with standard mechanical, hydraulic or electric tools."[99]	"Amos is becoming the benchmark in autonomous electric tractor production and sets the stage for the future of using technology and engineering across multiple platforms. With no operator fatigue, the tractor virtually never has to stop working until it is time for recharging. Simple transfer of operation data among tractors makes changing tasks easy."[100]
Power	25 or 50hp	50hp	75-85hp
Battery Runtime	5-10 hours	7-10 hours	4-8 hours
Charging Time	1.5 hours	2 hours	2 hours
Price	~$53,000	~$138,000	$185,000 (projected)

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