An Analysis of Retrofitting State of the Art Battery Cells in Chevrolet Volts and Older EVs to Cost Effectively Improve Range

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Introduction

Chevrolet Volts have a fanatical ownership base who love their cars. The batteries in Gen 1 cars are now 10 – 14 years old and Gen 2 Volts have batteries that are 6 – 9 years old. Volt owners report dealers quoting as much as $25,000 for new packs, if they can locate one, that have 10 – 15-year-old battery chemistries (87 Wh/kg for Gen 1 Volt batteries and 101 Wh/kg for Gen 2 Volt batteries). GreenTec offers a Gen 1 pack with original (refurbished) batteries and a 3-year warranty for $9,999 (shipping costs, taxes and installation costs are additional expenses) that provides a capacity of 7.8 kWh (vs. 11.1 usable kWh when new), per one purchaser. This equates to a range of about 30 miles. Used packs removed from scrapped Volts can be typically purchased for $2,000 to $3,000; these have very limited warranties and unknown capacities.

GM dealer prices for new packs exceed the value of low mileage 2019 Volts. Quality refurbished used packs with reduced capacity, e.g., GreenTec packs, exceed the value of many Gen 1 Volts.

This issue isn't unique for Volt owners. 10 year old and older EV and hybrid owners are also faced with purchasing expensive battery replacement packs to keep their cars operating at their original range.

Are there any other options for these owners to keep their cars on the road?

This paper assesses the feasibility, both technically and financially, of retrofitting GM Ultium battery cells into Gen 1 and Gen 2 Volt battery cases. It also investigates the feasibility of retrofitting new battery chemistries cost effectively into older EV and hybrid battery packs.

GM Ultium Battery Overview

Battery technology has advanced substantially since the Chevrolet Volt was first produced in 2011. The GM Ultium battery cell is representative of 2025 battery cell technology in terms of output, weight and cost. The Ultium's specific cell energy is 280 Wh/kg, or roughly three times more energy per kg than the Volt batteries. The Ultium battery cost is estimated at $100/kWh which is about 1/10 the cost of the original Volt battery. This means the Ultium cell has the potential to provide much more energy, in a smaller volume, at a lower cost, while saving weight vs. the original Volt batteries. This technology advancement also applies to ten year old EV battery packs.

Current Ultium modules, e.g., the Cadillac Lyriq EV module, use 24-cell modules with an 8S 3P* configuration; this configuration does not have enough voltage to meet the Volt requirements. This study develops the required module and pack S-P configurations using the Ultium cell to achieve a target nominal voltage of 360 V and a peak voltage of 395 V required for the Volt.

> *8 cells in series, 3 cells in parallel. A series configuration connects the plus terminal of one battery cell to the negative terminal of the next battery cell; this configuration increases the total voltage, e.g. four 20 volt, 10 amp cells in series have a voltage of 80 V and a current of 10 amps, 800 watts total. A parallel configuration connects each cell's positive and negative

terminals together; four 20 V batteries with 10 amp ratings create a 20 volt pack with 40 amps of current, 800 watts total.

The substantial increase in the specific battery energy density of current batteries and the order of magnitude cost reduction per kWh provide a significant opportunity to cost effectively retrofit Gen 1 and Gen 2 Volts, as well as older EVs and hybrids, with Ultium and other state of the art chemistry-based battery modules that can substantially increase range, reduce weight, and lower cost relative to new or refurbished original equipment batteries.

The below calculations verify that an Ultium based battery pack can be packaged in a Volt. meet voltage and current targets, substantially increase energy capacity, reduce weight, cost less than half of a new Volt battery pack and double the original Volt EPA range.

This study also includes financial projections showing the potential for an Ultium based Volt battery pack to generate millions of dollars in annual profits for the engineering company that develops these battery packages for Volts.

The potential to retrofit older EVs in 2026 is also analyzed. It is technically possible, but the near term opportunity, due to the wide availability of new packs and used cells, is not as financially viable as the Volt opportunity and has high risk due to competing directly with OEMs (original equipment manufacturers, e.g., Tesla). The projected 2030 battery specific energies and further cost reductions relative to 2026 cell prices could make retrofitting 15 and 20 year old EVs an attractive and financially viable enterprise in the 2030 timeframe.

Fundamental Assumptions

The below projections use c/o Volt software for SOC/DoD % (State of Charge/Depth of Discharge), peak current and voltage, and the same thermal limits. The higher capacity Volt Ultium pack cooling considerations are addressed separately later in this study.

Per the results of this study, an Ultium cell could provide ranges of 81 miles (vs. 38 miles for a Gen 1 Volt) and 105 miles (vs. 53 miles for a Gen 2 Volt) calculated using EPA reported ranges and usable kWh. Gen 1: 3.42 miles/kWh (38 mi. EPA rating/11.1 kWh usable capacity); and Gen 2: 3.79 miles/kWh (53 mi. EPA rating/14.0 kWh usable capacity) and usable 23.8 kWh (Gen 1) and 27.8 kWh (Gen 2) kWh Ultium packs. These ranges use the production Gen 1 (65%) and Gen 2 (76%) SOC/DoD battery utilization percentages. The very conservative Gen 1 SOC/DoD percent is a key contributor to the Gen 1 Volt's battery pack capability to still provide double digit range, typically 22 – 29 miles, after 14 years of service and a key reason its range is substantially less than the Gen 2 Volt (Gen 1 Volts had similar but slightly lower battery pack capacities, up to 17.1 kWh, vs. 18.4 for Gen 2 Volts).

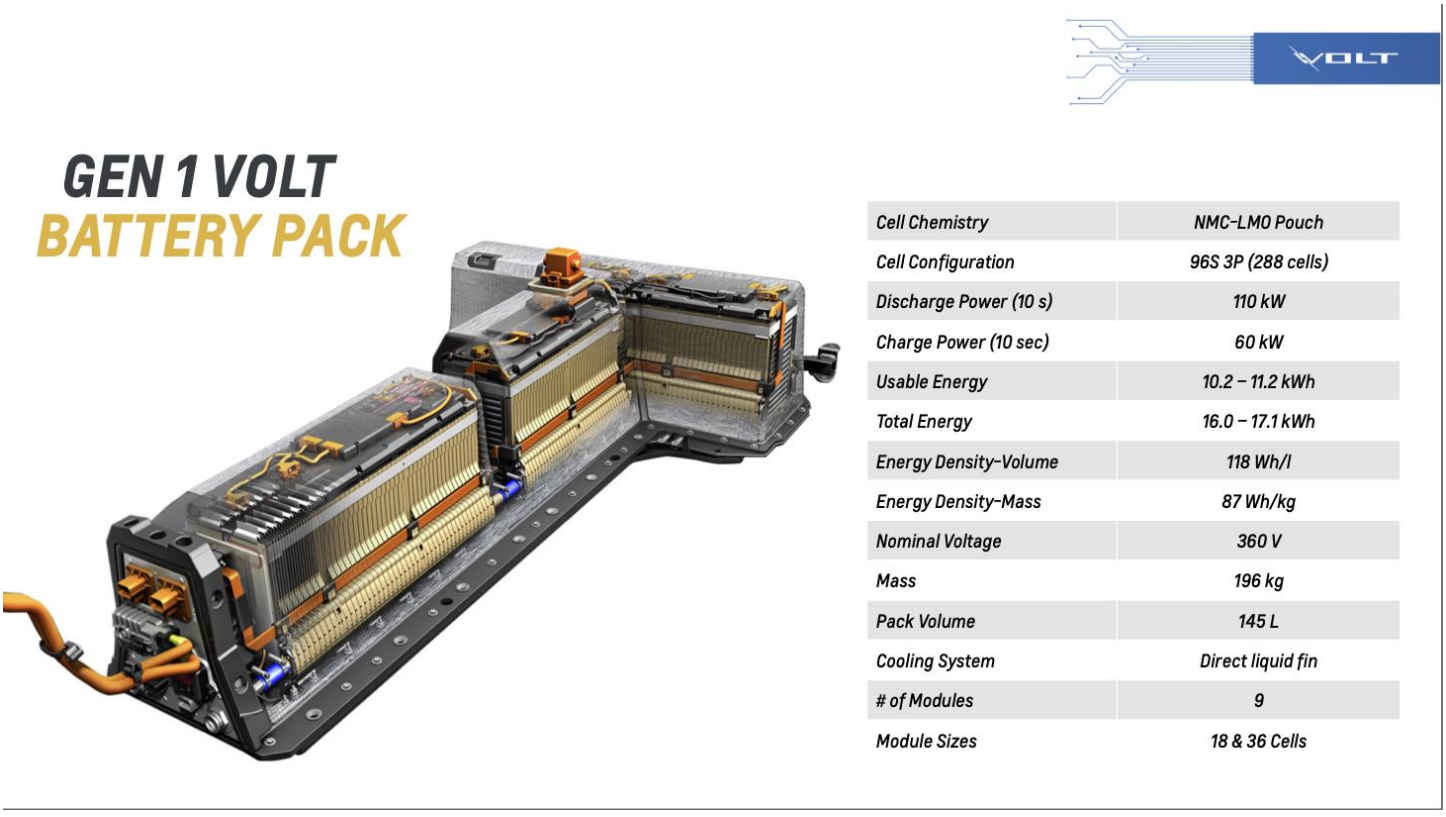
Note: The Ultium SOC/DoD % is 86.1% (212.7 kWh usable/246.8 kWh total = 86.1% for the Hummer EV) so the usable kWh could be increased by 10% (Gen 2) to 21% (Gen 1) if the software was reprogrammed to an 86% SOC/DoD ratio. However, due to the potential complexity of attempting to reprogram the Volt's SOC/DoD algorithms and unknown capability to do this, this study uses the production software SOC/DoD values for the Gen 1 and Gen 2 variants.

The production, unmodified Volt battery case is used to house the Ultium cells for both the Gen 1 and Gen 2 Volt. Additionally, the production Volt software is maintained to control: 1. Peak current; 2. SOC/DoD limits (65% Gen 1 and 76% Gen 2); and 3. Thermal limits. The carryover Volt inverter is used for both Gen 1 and Gen 2 applications since the peak current and the peak voltage remain the same for the Ultium battery pack.

Thermal Management System Overview

The operational efficiency of the Ultium battery is higher than the original Volt batteries which means there will be less heat generated by the battery pack during vehicle operation. Additionally, the weight of the new pack is over 100 lbs. less than the original pack. The new packs have three less modules for Gen 2 and five less modules for Gen 1. These factors, less heat loss per cell and less thermal mass to heat or cool, mean that the original battery cooling system could have sufficient capacity (BTU/minute) to cool the higher kWh Ultium battery pack.

The original cooling system does need to be evaluated to determine if it is capable of heating and cooling the Ultium batteries in worst case conditions. It is a possibility that a larger heat exchanger and/or a higher flow coolant pump may be required to thermally control the higher capacity Ultium battery pack.



Cell Chemistry	NMC-LM0 Pouch
Cell Configuration	96S 3P (288 cells)
Discharge Power (10 s)	110 kW
Charge Power (10 sec)	60 kW
Usable Energy	10.2 – 11.2 kWh
Total Energy	16.0 – 17.1 kWh
Energy Density-Volume	118 Wh/l
Energy Density-Mass	87 Wh/kg
Nominal Voltage	360 V
Mass	196 kg
Pack Volume	145 L
Cooling System	Direct liquid fin
# of Modules	9
Module Sizes	18 & 36 Cells

Cell Chemistry	NMC-LMO Pouch
Cell Configuration	96S 2P (192 cells)
Discharge Power (10s)	120 kW (+9%)
Charge Power (10s)	60 kW
Usable Energy	14.0 kWh (+25%)
Total Energy	18.4 kWh (+8%)
Energy Density-Volume	119 Wh/l (+1%)
Energy Density-Mass	101 Wh/kg (+16%)
Nominal Voltage	360 V
Peak Voltage	395 V
Peak Current	430 A
Mass	183 kg
Pack Volume	154 L
Cooling System	Direct liquid fin
# of Modules	7
Module Sizes	24 & 32 Cells

Gen 1 and Gen 2 GM Battery Pack Data Link:

https://media.gm.com/content/dam/Media/microsites/product/Volt_2016/doc/VOLT_BATTERY.pdf

Battery Pack Design

An Ultium battery cell has a peak voltage of 4.2 V, a nominal voltage of 3.7 V, a rating of 103 amp-hours and weighs 3 lbs. As mentioned at the outset, the production General Motors 8S 3P Ultium module, comprised of 24 cells, is not a workable configuration for this upgrade due to its low voltage. Even at its peak voltage of 33.6 V, there is not enough energy for the maximum number of Ultium modules that will fit in a Volt battery case, nine total, to meet 395 V peak and 360 V nominal voltages (9x 33.6 V = 302.4 V). It is necessary to design a module that will meet the target voltages, the target current and package within the existing Volt battery case.

Packaging Part 1: Ultium Battery Stack Height Determination

The Gen 1 Volt pack cell specific volume (Wh/l) is 118 Wh/l; the Gen 2 Volt specific volume is 119 Wh/l. The Ultium cell specific volume is 630 Wh/l; this is about 5x less volume per kWh than the production Volt batteries and an initial indicator that the increased capacity Ultium battery modules will fit successfully in the Volt battery case. The Ultium pouch cell measures 23” x 4” x 0.4”.

The Volt’s battery case dimensions are 63” long (center tunnel), 35.4” wide at the rear (the “T” section), 15.75” wide in the tunnel and 11.81” high. The Ultium battery module height cannot exceed 11.81”.

The Volt cooling fin plates will be utilized to cool the batteries; each plate is 1 mm thick (0.039”) and is placed between each cell. Stacking 24 cells to match GM’s production Ultium module configuration means there are 25 cooling plates contacting the top and bottom of each cell which have a total height of 0.975” (25 x 0.039”).

24 Ultium cells have a total height of 9.6” (24 x 0.4” cell height); 9.6” + 0.975” = 10.575”. This allows a clearance of 1.235” (11.81” case height – 10.575” battery and cooling plate stack height); this distance is sufficient for thermal expansion and vibration/shock countermeasures, if required.

A 24 cell Ultium battery meets the height criteria, including cooling plates.

The next questions Is: can a 24 cell Ultium module meet the Volt’s energy, power, voltage and current requirements.

Packaging Part 2: Module Voltage Derivation

24 Ultium cells stacked to make one module yield possible voltages of:

24S, 1P: – Peak voltage: 100.8 V (4.2 V x 24) @ 103 amp-hours; Nominal voltage: 88.8 V (3.7 V x 24) @ 103 amp-hours.
12S, 2P – Peak voltage: 50.4 V (4.2 x 12) @ 206 amp hours; Nominal voltage: 44.4 V (3.7 V x 12) @ 206 amp-hours.
6S, 4P – Peak voltage: 25.2 V (4.2 V x 6) @ 412 amp hours; Nominal voltage: 22.2 V (3.7 V x 6) @ 412 amp-hours.

The 24S 1P configuration is the obvious choice; it needs the least number of modules (four) to meet the peak voltage requirements. The peak voltage for a 4S module packaging configuration is 403.2 V (100.8 V x 4); this is 2% greater than the 395 V peak target and could be limited to a 395 V SOC charging shut off voltage. The nominal voltage is 355.2 V (88.8 V x 4); this is within 1.3% of the 360 V nominal target. The 12S 2P configuration will meet the voltage requirements but requires 8 modules; this will add weight and cost relative to the 24S 1P configuration but is an option that would quadruple the Volt’s original battery capacity. The 24S 1P configuration is the lightest weight, lowest cost solution that meets the criteria of cost effectively increasing the Volt range substantially.

The next step is to determine if four 24 cell 24S 1P modules can be packaged in the confines of the production Volt’s battery case.

Packaging Part 3.: # Modules That Can Fit in the Battery Case Center Section

The battery pack center case dimensions are 63” L x 15.75” W x 11.81” H. Three 24 cell modules (12” wide) can be packaged transversely in the 15.75” wide case. Two 24” modules (48” long) can be

packaged longitudinally in the 63” long section. A total of six 24 cell modules can be packaged in the center section.

Packaging Part 4.: # Modules That Can Fit in the Battery Case “T” Section

The dimensions are 35.4” L x 15.75” W x 11.81” H. Three 24” long x 4” wide modules can be packaged in the rear section.

This yields a total of nine 24 cell Ultium modules that can be packaged in a Volt battery case.

The simplest approach is to package four modules in the center section and leave the rear “T” section empty.

Energy Capacity Calculation

The maximum capacity (kWh) at peak voltage for each 24S 1P Ultium module is 10.4 kWh ((100.8 V x 103 amp-hours/1000)); four modules will provide 41.6 kWh of peak battery capacity. The nominal capacity (kWh) at nominal voltage for each 24S 1P Ultium module is 9.15 kWh ((88.8 V x 103 amp-hours/1000)); four modules will provide 36.6 kWh of battery capacity. Using the nominal capacity and applying the Volt’s SOC/DoD values, the Gen 1 Volt will have a usable capacity of 23.8 kWh (36.6 kWh x 65%) and the Gen 2 Volt will have a usable capacity of 27.8 kWh (36.6 kWh x 76%). This increases the Gen 1 Volt’s battery capacity by 2.14x (23.8/11.1) and the Gen 2 Volt’s battery capacity by 1.99x (27.8/14.0) relative to their original (new) capacities. This Ultium four module battery pack doubles the usable battery capacity for both generation Volts.

The next step is to verify that the Ultium pack can meet the peak current requirement of 430 amps and power the motor to its 120 kW peak (110 kW peak for the Gen 1 Volt motor).

Current Calculation

The Gen 2 current and motor power requirements are used as the target for this calculation as the Gen 2 peak motor power is higher than the Gen 1 motor. The Gen 2 peak current is 430 Amps at a peak voltage of 395 volts. The Gen 2 pack is restricted to peak current for ten seconds at its 120 kW peak motor power and 60 kW peak charging power.

Current limiting is done universally by OEMs on their EV’s to protect motors, inverters, wiring, and batteries from overheating. Temporariy allowing high current levels provides substantially improved acceleration; ten seconds is a typical maximum duration for peak current which is the equivalent of wide-open throttle for an ICE vehicle. The Gen 1 Volt will hit 60 MPH in about 9 seconds; the Gen 2 Volt will hit 60 MPH in a little over 7 seconds; higher current will improve merging with freeway traffic and enhance city traffic responsiveness. The production Gen 2 inverter reduces the maximum current level after ten

seconds; if thermal limits are reached before that, the current will be limited to less than ten seconds of maximum current draw.

The 24S 1P module, with four modules wired in a 4S configuration, has 103 amp-hours. To determine the peak current duration, the amp-hours are divided by the peak current. The time duration is 0.24 hours,14.4 minutes (103 amp-hours/430 amps); it will take 14.4 minutes to fully discharge the Ultium battery at a continuous 430 amp current draw. This is a C rate* of 4.2. The C rating for the Ultium battery is 6C so this discharge rate is well within its capability. This time is adequate to meet the ten second 430 amp requirement (worst case) and will allow 86 consecutive ten second bursts at 430 amps before fully discharging the battery, an unlikely scenario.

- C rate is the ratio of amp-hours/discharge or charging current; it can also be expressed as 1 hour/time in hours to fully discharge a battery at a specified current level, e.g. 1/0.24 hours = 4.2; at a C rate of 4.2, a 103 Ah cell will be fully discharged in 0.24 hours at a current of 430 amps.

The calculated current for 120 kW motor operation at peak voltage is 304 amps (120,000 watts/395 V) and 333 amps at nominal voltage (120,000 watts/360 V). These figures do not reflect voltage drops due to I^2R losses. The voltage must drop to 279 V to reach a 430 amp level at a 120 kW motor power level. The time duration for operation at peak voltage for a 120 kW power output is 0.34 hours, 20.3 minutes, and 0.31 hours, 18.6 minutes, at the nominal voltage; these are longer duration than at the 430 amp peak current draw.

Note that the actual calculated 120 kW motor current level is substantially lower than the design peak of 430 amps. The production battery and inverter are engineered to provide 155 kW to the motor at nominal voltage ((430 A/333A) x 120 kW) and 170 kW to the motor at peak voltage ((430A/303A) x 120 kW). These are power level increases of 29% (nominal voltage) and 42% (peak voltage).

Final Battery Pack Configuration

Four Ultium modules with 24 cells arranged in a 24S 1P configuration and combined in a 4S module configuration will meet voltage, current and capacity requirements and will package in the existing Volt battery cases.

The above analysis verifies the technical feasibility of retrofitting Ultium batteries into Gen 1 and Gen 2 Volts.

Volt Acceleration Potential with Ultium Batteries

A basic online 0-60 calculator (using HP, weight, drive wheel location and transmission type as inputs – this calculator is based on actual vehicle performance data measured by enthusiast magazines) predicts a 155 kW power level would reduce the 0-60 time by 1.5 seconds vs. the 120 kW Gen 2 (Car and Driver

recorded a 0-60 time of 7.4 seconds in “Hold” mode for a Gen 2 Volt); this translates to a 5.9 second 0-60 time. The estimated 0–60-time reduction for the 170 kW motor power level is 2.0 seconds or a 5.4 second run (5.1 seconds using Motor Trend’s 7.1 second 0-60 time published for the Gen 2 Volt).

This power increase would move Volt acceleration times closer to current EVs and be as quick to 60 MPH as many base EVs with single motors and smaller battery packs. However, many Tesla models accelerate to 60 MPH in 4 seconds or less and out accelerate high horsepower sports cars; the 2024 Model 3 Performance model does 0-60 in 2.8 seconds. And the 2022 Model S Plaid does 0-60 in 2.1 seconds. A 170 kW Volt would not have this level of performance but could give older Volts contemporary EV acceleration levels at city traffic speeds.

The Volt’s acceleration will fall off rapidly at higher speeds, even with the substantially increased power. The maximum possible motor output of 170 kW is only 228 HP, which is a lb./HP ratio of 15.5 in a 3,525 lb. car. For comparison, the 2024 Tesla Model S Performance lbs./HP ratio is 7.9 lbs./HP (4,046 lbs./510 HP).

The improved 0-60 speed acceleration would also reduce the 0-30 times, and make the Volt, with published 0-30 times of 2.1 seconds (MT) and 2.5 seconds (C&D), competitive with many of its higher performance Chevrolet ICE stablemates, including the Corvette.

The author could not find an online 0-30 MPH calculator, so he created a “first principles” math model to calculate 0-30 times based on the formula “A= F/M, where F is the force in lbs. (calculated by converting HP to ft.lb./second – 1 HP = 550 ft. lbs./second, and dividing that product by the final velocity, 30 MPH), M is the vehicle mass in slugs, and A is acceleration in ft/sec^2. The baseline acceleration with the 120 kW motor was calculated using a car weight of 3,525 lbs. (published by Car and Driver). The time to accelerate to 30 MPH was iterated until it created a velocity of 44 ft/sec (30 MPH) and this value was then compared to Car and Driver’s recorded 0-30 time of 2.5 seconds. The author’s model predicted 2.4 seconds for the 120 kW motor 0-30 time, an error of 0.1 second, i.e., the model was within 4% of C&D’s actual measured time, a reasonable approximation. This low speed model does not include aerodynamic losses, an exponential function, nor does it reflect increasing tire load force as a function of vehicle speed. The 0.1 seconds quicker time is a result of these missing factors. This low speed model approximation requires that the tire force (tire coefficient x vehicle weight) and the aerodynamic drag force (4 times higher at 60 MPH than at 30 MPH – Cd x r x A_F x $V^2$where Cd is the coefficient of drag, r is the air density, A_F is the vehicle frontal area, and V is the vehicle velocity squared) be included to be accurate at higher speeds where these forces become much more significant.

The low speed 120 kW model was then run with the 170 kW motor using the same vehicle mass and the acceleration rate was re-calculated. The time was iterated until a velocity of 44 ft/sec was achieved at the new acceleration level (V = A x T, Velocity = Acceleration in ft/sec2 x Time in seconds). The estimated 0-30 time was 1.7 seconds, a 0.7 second reduction vs. the 120 kW base vehicle. The modeling error of 0.1 seconds was added to the 1.7 second math model prediction to create an estimated 1.8 second 0-30 time. Because force is linear in these low speed approximations, the acceleration time with a 42% more powerful motor is 42% quicker, a confirmation of the low speed models accuracy. The 455 HP C7

Corvette's 0-30 times, recorded by Car and Driver, were 2.3 seconds for the manual and 1.8 seconds for the automatic.

It is possible that a Volt with a 170 kW tune could, with tires that have adequate traction, be competitive in 0-30 runs with ICE sports cars with double the Volt's possible 228 HP (170 kW) tune.

To put the high speed performance of the C4 and C7 in perspective, per Car and Driver, the C4 Corvette has a top speed of 165 MPH and the C7 has a top speed of 190 MPH vs. the Volt's governed 102 MPH top speed.

The production Gen 2 Volt battery/inverter system, per the GM data sheet presented earlier, has been engineered to deliver a peak of 170 kW. This available performance would not impact the range when the car is driven at production power levels, i.e., at 120 kW or less.

Battery Weight Analysis

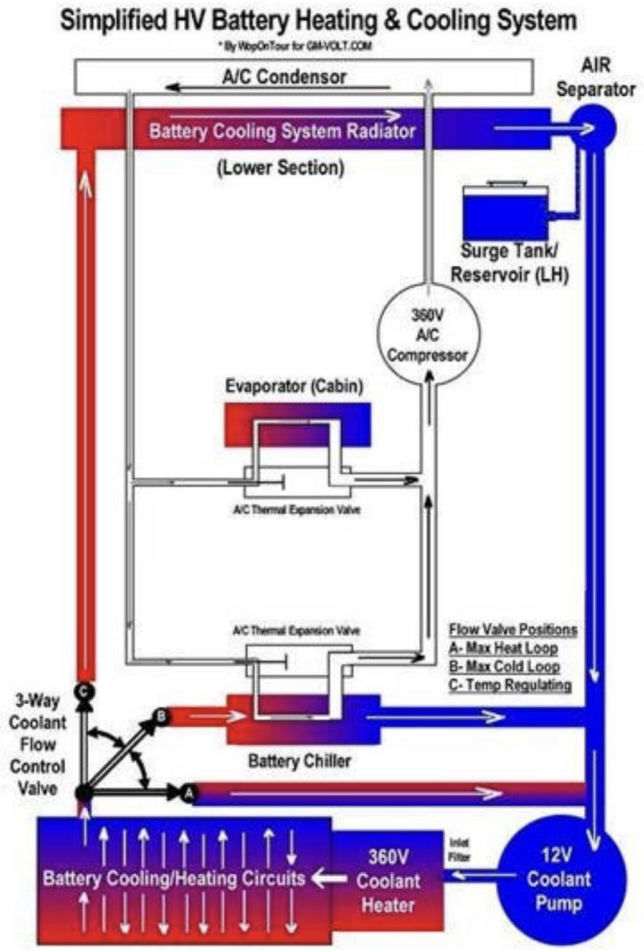
Each Ultium cell weighs 3 lbs. (1.36 kg). There are 96 Ultium cells in the Volt pack (24 cells/module x 4 modules). The weight of the Ultium batteries in a four module pack is 288 lbs. (96 cells x 3 lbs./cell). The weight of the Gen 1 battery cells is 424 lbs., and the weight of the Gen 2 battery cells is 402 lbs. The Ultium battery packs are over 100 lbs. lighter than the original Volt battery packs. As detailed in the section above, the Ultium battery specific energy is 3x higher (1/3 the weight per kWh) than either Volt's battery, so reduced weight is an expected outcome.

Because vehicle efficiency is related to weight (a 10% weight reduction yields a 6% to 7% increase in vehicle efficiency), Volts fitted with the lighter Ultium battery pack would be slightly more efficient (Gen 2 example: 3,525 lbs. – 114 lbs. Ultium weight savings = 3,411 lbs.; 3,411 lbs./3,525 lbs. = 0.968; 0.6 x 0.032 = 0.019 or a 1.9% projected efficiency increase. 1.019 x 3.79 miles/kWh = 3.86 miles/kWh. 3.86 miles/kWh x 27.8 kWh = 107.4 miles. This weight savings, an ancillary benefit, would add over 2 miles of additional range to both Gen 1 and Gen 2 Volts. While this is a small number, 2 miles is 15% of a 2025 Honda Accord PHEV Hybrid's electric range (13 miles).

Ultium Battery Heating and Cooling Thermal Limits

The Volt batteries perform optimally between 77 F and 86 F; per GM, operation between 50 F and 104 F does not significantly degrade battery performance but is not ideal. The combination of low SOC/DoD percentages and maintaining an optimum battery temperature are key elements that prolong battery life. The Ultium battery pack temperature range is maintained between 68 F to 77 F; it is not known if the Volt software can be revised to reflect these lower values. Additionally, it is not known if the Volt's thermal management system can maintain these lower temperatures.

Worst case, the original Volt temperature range of 77 f to 86 F is a reasonable and mild operational range for battery function and is considerably better than the 50 F to 104 F range that has little impact on the original Volt's battery performance. The impact on range and life by running at 77 F to 86 F is expected to be minimal, especially considering the Ultium battery would be operating at the more conservative Gen 1 and Gen 2 Volt SOC/DoD levels (65% & 76%) relative to production Ultium levels (86%), 21% and 10% lower SOC/DoD levels respectively.



Volt Thermal Management System

Link to Volt Cooling System Review: https://www.gm-volt.com/threads/the-chevrolet-volt-cooling-heating-systems-explained.336535/

Timing and Cost Projections

The Volt undertaking is estimated to take 12 - 18 months (possibly less, depending on the supplier's experience, engineering staff size, and finances) to reach production readiness for an experienced firm with GM financial connections (for contracting battery purchases) and available manpower, making late 2026 the probable start of initial, low volume production. Per a Goldman Sachs study*, they project a cost of $80/kWh for batteries in 2026, including for the General Motors Ultium battery. The target purchase price for a 2026 Ultium battery contract with GM is $120 kWh to $160 kWh. The respective cost estimates for the Gen 1 and Gen 2 36.6 kWh battery pack, using these target purchase prices for the Ultium cells, are $7,320 and $9,150 for a pack that doubles their original range.

The projected cost for either a $200/kWh retail price pack ($120/kWh purchase price) or the $250/kWh retail price pack ($160 kWh purchase price) is less than the GreenTec pack using refurbished batteries that provided a 30 mile range for a Gen 1 Volt.

These numbers are used below in the Income Potential analysis.

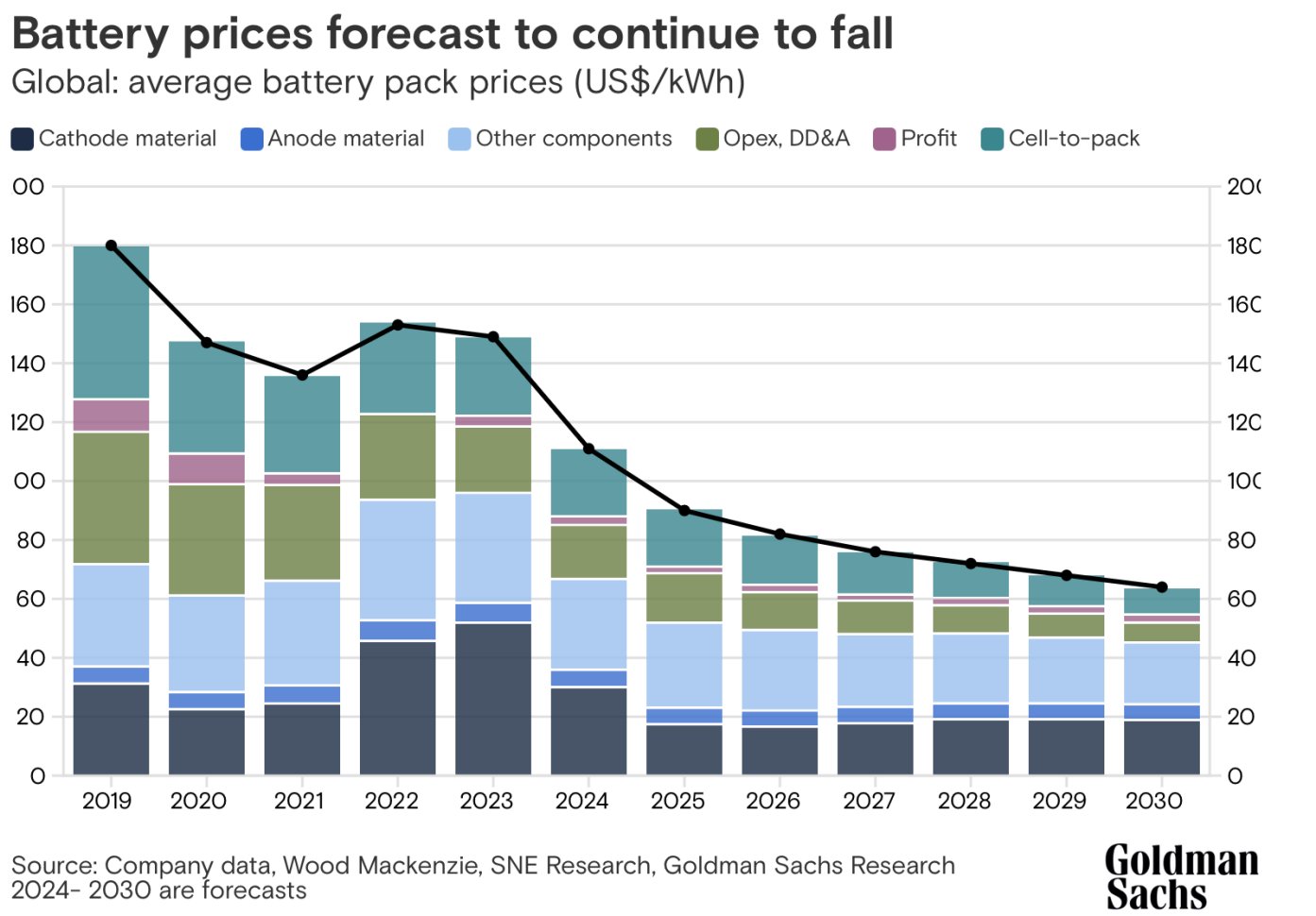
It is important to recognize that battery costs are projected to continue to decrease below $80/kWh. In five years, the cost is projected to be $60/kWh or less. This would make a $150/kWh retail cost for an Ultium (or equivalent) Volt retrofit battery financially viable for a supplier. The chart below projects a cost of $5,490 for this pack. Additionally, the battery specific energy is continuing to go up.

Many projections show even lower battery costs and predict 400 Wh/kg (or higher) by 2030. The think tank, Rocky Mountain Institute, estimates are included below (link: https://rmi.org/the-rise-of-batteries-in-six-charts-and-not-too-many-numbers/#:~:text=RMI%20forecasts%20that%20in%202030,with%20BNEF's%20Net%20Zero%20scenario.):

RMI forecasts that in 2030, top-tier density will be between 600 and 800 Wh/kg, costs will fall to $32–$54 per kWh, and battery sales will rise to between 5.5–8 TWh per year. To get a sense of this speed of change, the lower-bound (or the "fast" scenario) is running in line with BNEF's Net Zero scenario.

The impact of a 600 Wh/kg, $43/kWh ($54 +$32 = $86/2 = $43 average) battery in five years on a Volt retrofit battery pack with 2030 batteries is substantial. Using the 2026 values from this report, the specific energy increase is 600/280 or 2.14; this means the weight of the 2026 derived 36.6 kWh pack is 288/2.14 or 135 lbs. This could halve the number of Volt cells from 96 to 48 (dependent on cell voltages). The retail cost per cell for the most expensive 2026 variant is $9,150; the cost per cell is $9,150/96 = $95. $95/1.86 ($80/$43) = $51/cell x 48 = $2,452. Based on the RMI report, it is possible that a 36.6 kWh Volt battery pack could cost less than $2,500 by the year 2030.

The message is certainty clear for Volt and older EV owners: continuing improvements in battery chemistries that can double the range of EV's and hybrids and that can create battery packs that sell for substantially less than 2026 prices are a strong possibility within the next five years.



*Link: https://www.goldmansachs.com/insights/articles/electric-vehicle-battery-prices-are-expected-to-fall-almost-50-percent-by-2025

Study Summary

Ultium 24 S 1 P 4 S Configuration	Original Range in Miles	Projected Ultium Range in Miles	Production Usable kWh	Production Total kWh	SOC/DoD	Miles/kWh - EPA	Ultium Total kWh	Ultium Usable kWh	Ultium weight Savings - lbs.	Retail Projections at $250/kWh	Retail Projections at $200/kWh	Retail Projections at $150/kWh
Gen 1 Volt w/Ultium Battery Pack	38	81	11.1	17.1	65%	3.42	36.6	23.8	136	$9,150	$7,320	$5,490
Gen 2 w/Ultium Battery Pack	53	105	14.0	18.4	76%	3.79	36.6	27.8	114	$9,150	$7,320	$5,490

The EV Battery Retrofit Business Opportunity

It is reasonable to expect that owners of not only Volts (the focus of this article), but other older EV's and hybrids, with owners as enthusiastic about their electric cars as the Volt community, would like to take advantage of ongoing battery advancements to upgrade older EVs to increase their range. This is an opportunity for an aftermarket EV engineering center to design retrofit packs with state of the art battery technologies to fit older vehicles, potentially doubling their range at an affordable cost.

As exemplified by this study, it is straightforward to develop S-P configurations that maximize voltage and minimize module count based on specific cell specifications. Similarly, packaging new cells into existing battery case configurations is an equally straightforward design exercise.

The economies of scale generated by offering packs for hundreds of EV models could reduce retrofit prices further as well as substantially increase the available market for this product. There are numerous companies, e.g., GreenTec, Lingenfelter Performance Engineering, New Eagle, etc., that have the knowledge and experience to lead this development with potential licensing to nationwide automotive service chains that could be trained and authorized to distribute and install their retro packs. This could also include licensing regional US battery pack retrofitting centers to provide more convenient local installation centers allowing people to drive their cars in and drive out with a fresh pack in one day, eliminating shipping costs for many owners.

This could also lead to the development and installation of high performance, engineered tuner packages, i.e., software upgrades, available as part of battery pack upgrades, that could include reprogramming higher short term motor peak currents, e.g., +142% for ten seconds and 100% after ten seconds, to improve Volt acceleration and take advantage of the newer battery cell capabilities. This upgrade should be limited to vehicles fitted with new batteries only, not vehicles with ten to fifteen year old packs. The Volt batteries have an AI online reported 7.8 C rate but stressing these older cells by increasing the short term current level by 42% is not recommended by the author.

The Volt battery and inverter are rated at 430 amps peak current. At 430 amps, at a peak voltage of 395 V, this equates to 170 kW of power. At the nominal battery voltage, 360 V, this is 155 kW of power at 430 amps. Chevrolet limits the Gen 2 Volt motor peak power to 120 kW (110 kW for the Gen 1) even though the battery/inverter can provide 35 to 50 more kW than the motor power limit of 120 kW. There is conflicting information about whether the Volt motor power can exceed 120 kW for short durations and how much more power the motor can handle without long term issues.

However, motor life is directly related to temperature; EVs current limit the motors at high temperatures to protect the motors from overheating and this protection would remain in place for these upgraded battery packs. If the Volt motor temperature remains below the upper thermal limit for ten seconds at a 170 kW power level, the impact on motor life should be null and the customer could enjoy the full motor output for the entire ten second duration. High ambient temperatures could reduce the ten second duration at high current levels. The existing production thermal management system would current limit the motor, i.e., it would be the primary control to reduce a 155 kW or 170 kW motor input if the temperature reached the upper limit before the motor ran for its programmed duration of ten seconds at 155 kW or 170 kW.

A 170 kW discharge rate is well within the Ultium battery capabilities and should not stress an Ultium based battery pack. The Ultium battery was engineered for high C rates. The Hummer EV uses an Ultium battery pack, and its motors draw 619 kW at peak output, over three times as much power as an uprated Volt motor operating at the inverter current limit. Additionally, the Ultium battery can be charged at 350 kW; this means the Volt Ultium 36.6 kWh battery pack could theoretically be charged from 0% to 100% SOC in 6.3 minutes (36.6 kWh/350 kW) and in less than 5 minutes at their production SOC/DoD capacities.

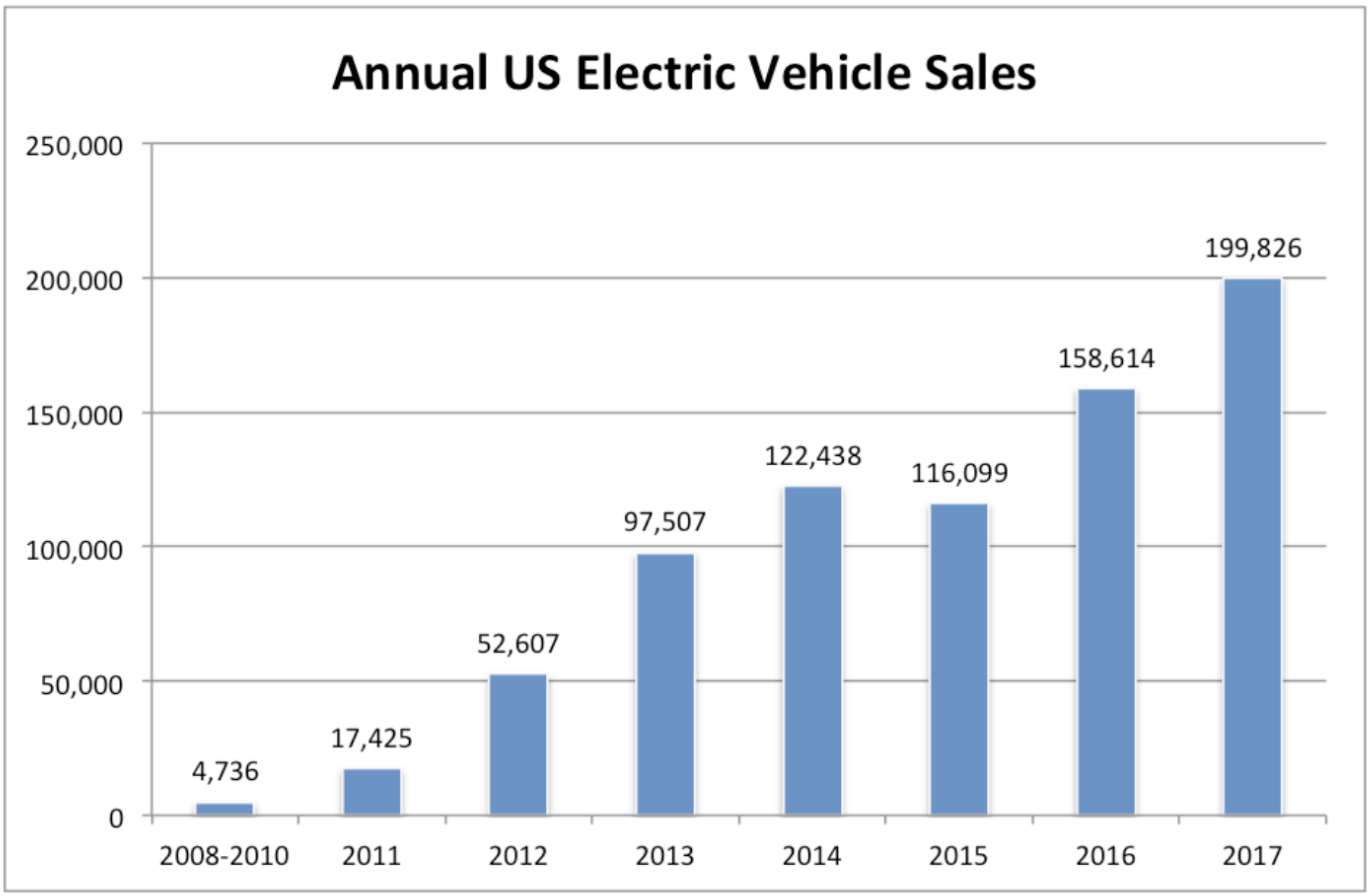
Developing a 350 kW charging system for a Volt fitted with an Ultium pack is another potential opportunity for a company that develops a Volt Ultium battery pack.

The Hummer battery pack charge rate (kWh added/time unit) can be derived as follows (using GM published data): 100 miles added in ten minutes; miles/kWh efficiency = 1.5 (worst case); maximum possible kWh added in ten minutes: 66.7 kW (100 miles/1.5 miles/kWh); 66.7 kW added in ten minutes at a 350 kW charging rate. This verifies the above estimate for the Volt's charging time.

Key questions are: 1. What could the annual volume of retrofitted (non-Volt) EVs be? and 2. What would the financials look like? The following section provides some projections relative to these questions.

Used EV Market Analysis

There were 410,000 2015 and earlier EVs and Volts sold in the US; these vehicles have ten to fifteen year old battery packs. Using the Volt's 60% survivor rate, this means there are about 246,000 10 to 15 year old EVs still on the road. A 2% take rate for improved battery packs yields about 4,920 potential customers.



EV Sales Source: Inside EVs Sales Scorecard

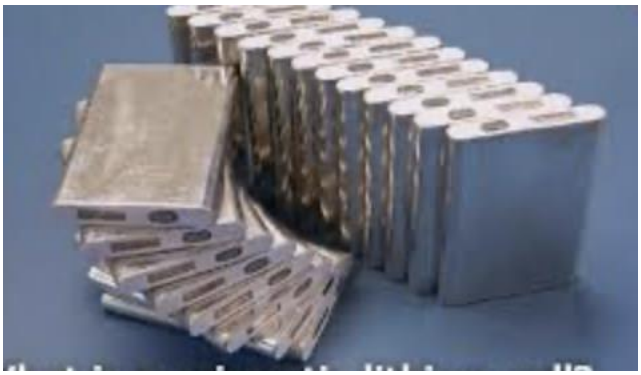
Link: https://evadoption.com/ev-statistics-of-the-week-historical-us-ev-sales-growth-market-share/

It is important to differentiate between the battery cell types to break out the business opportunities.

EV Battery Cell Types

As noted above, Tesla and GM use two different cell types. Tesla uses cylindrical cells, including 18650 cells (earlier models), 18 mm diameter x 65 mm long, 21700 cells (in more recent models), 21 mm diameter x 70 mm long, and, lately, 4680 cells, 46 mm diameter x 80 mm long; these cylindrical cells look like a large AA battery. The new Rivian R2 is using a 4695 cylindrical cell, a 46 mm diameter x 95 mm long configuration. Rivian claims this cell has 6 times the capacity of its previous 21700 cell. This would be the current cell of choice for retrofitting 18650 cells. The GM Ultium pouch cell, described previously, is 24" long, 4" wide and 0.4" thick. There is also a third cell type, called a prismatic cell, which is used in EVs.

A prismatic cell is typically a square or rectangular shape; examples of prismatic cells are pictured below.



Each cell type has advantages and disadvantages; all three types are used by EV OEMs.

Cylindrical cells are used by Tesla, Rivian, and Lucid. Cylindrical cells are currently the most widely used battery cells. Pouch style cells are used by General Motors, Hyundai, Ford, Nissan and Renault. Prismatic cells are used by Audi, BMW, Volkswagen and Tesla.

Battery packs using pouch and prismatic cells use fewer cells than battery packs using cylindrical cells. This makes them simpler to disassemble and reassemble than cylindrical packs, which can contain over 8,000 cells. Cylindrical cells are typically installed in a battery pack using automated equipment; removing and replacing 8,000 battery cells by hand would be a time consuming, labor intensive, expensive effort. Automated robots that remove and install, or install only, cylindrical batteries, as discussed in a possible scenario below, would be a requirement to make retrofitting higher performing cylindrical batteries profitable. This would be a significant expense for a new battery retrofitting venture. There would be additional engineering required as well, to revise a battery pack, originally designed for a 18650 cell, to accept and cool a 4680 cell, which is 28 mm larger in diameter and 15 mm longer.

The following video shows the complexity of replacing a single cell in a Tesla Model 3 pack with 5,500 cells: https://www.youtube.com/watch?v=1-TF5MSDJ6Q. It is likely that a new module will be needed to house 4680 batteries in a space where 18650 cells formerly resided; four new 4680 modules (with fewer cells) would then replace the four original 18650 cell modules shown in the video.

Because of the expense and time required to design, build, program and develop an automated battery cell pick and place, or place only, sighted robot (to automatically differentiate between cell diameters), and the engineering effort required to redesign earlier packs to accept larger, more powerful cells, it is recommended that the initial focus for updating older battery packs with more powerful new cells be initially limited to pouch and prismatic cells.

It is also a possibility that the engineering required to successfully update cylindrical cell packs is beyond the capabilities of even highly skilled aftermarket EV companies. The cost and time of the ER & D required to develop a profitable cylindrical cell replacement program could be a total loss.

Despite the popularity of cylindrical cells, there are still a significant number of vehicles made by major OEMs fitted with pouch and prismatic cell types. One estimate indicates 45% of 2025 EVs will use pouch style batteries. This provides an adequate number of candidate EVs, and the simplicity of these

conversions, and the profits, could accelerate the scale-up to higher volume, robotically controlled, cylindrical cell, retrofits. Retrofitting existing packs with more easily packaged battery cells, i.e., pouch and prismatic cells, and using a limited number of cells (a 72 kWh prismatic pack typically has less than 600 cells; the 36.6 kWh Ultium Volt pack uses 96 cells) will minimize labor hours, reduce the build complexity, minimize tooling and assembly line costs, and potentially allow using one common pouch cell and one common prismatic cell for all conversions. This approach could provide increased economies of scale which could lower costs.

The profits from retrofitting lower volume pouch and prismatic cells, combined with Volt profits, could help pay for the ER&D to develop robots capable of quickly and accurately retrofitting older cylindrical cell packs with higher performance cells and cover the cost of these machines.

Analysis of Current EV Battery Replacement Costs (Tesla Example)

Per an online source*, new Tesla battery packs from Tesla for a Model S range from $12,000 - $15,500. Taxes and labor are not included in this price. Tesla does not publish battery pack prices at their online parts catalogue. This equates to costs of $160/kWh for the 75 kWh battery pack ($12,000/75 kWh) and $155/kWh for the 100 kWh battery pack ($15,500/100 kWh).

The 2025 Tesla Model S has a range of 348 miles with a 75 kWh (72.5 kWh usable) battery pack which is an efficiency of 4.6 miles/kWh (348 miles/75 kWh = 4.6 miles/kWh) and 410 miles with a 100 kWh (95 kWh usable) battery pack which is an efficiency of 4.1 miles/kWh (410 miles/100 kWh = 4.1 miles/kWh). The reduction in efficiency can be primarily attributed to the added weight of the100 kWh battery pack.

Current GreenTec refurbished batteries for Tesla Model S batteries (May 2025 online prices):

100 kWh: $15,500; 300 mile range; 3.0 miles/kWh; $155/kWh;
90 kWh: $11,999; 260 miles range; 2.89 miles/kWh; $133/kWh;
85 kWh; $9,999; 230 miles; 2.71 miles/kWh; $118/kWh;
75 kWh; $5,999; 190 miles; 2.53 miles/kWh; $80/kWh.

*Source: https://www.findmyelectric.com/blog/tesla-battery-replacement-cost-explained/

The efficiency of the refurbished (used) 100 kWh Tesla battery pack is 3.0 miles/kWh vs. 4.1 miles/kWh for a new pack. The efficiency of the refurbished (used) 75 kWh Tesla battery pack is 2.53 miles/kWh vs. 4.6 miles/kWh for a new pack.

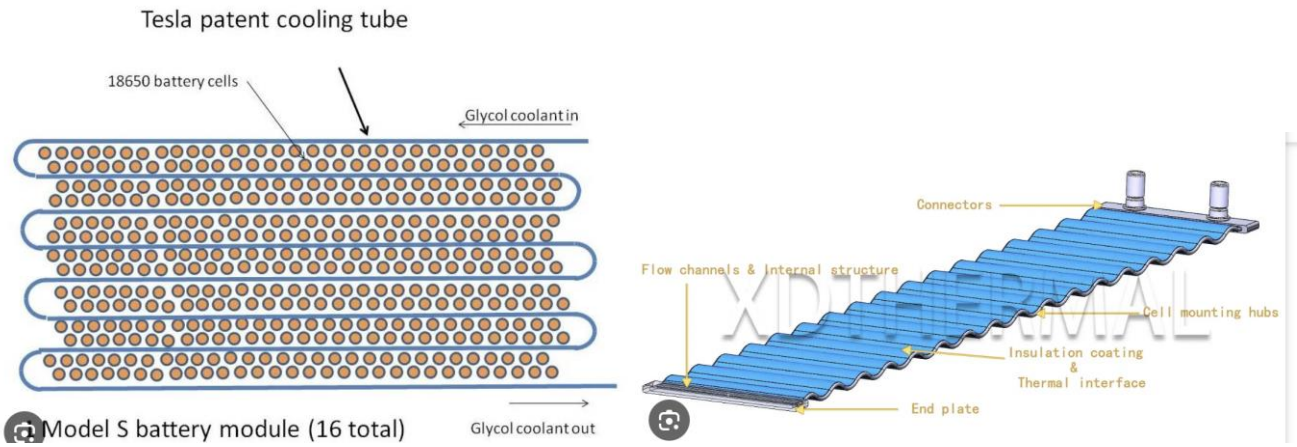
The EV $/kWh prices are substantially lower on a $/kWh basis than the Volt GreenTec replacement pack cost of $585/kWh ($9,999/17.1 kWh). This may be due to the economies of scale from Tesla's high volume battery production and large scale used battery availability.

The opportunity to profit in this (non-Volt) EV market is unlikely in 2026. At the estimated lowest target purchase price from GM, the Ultium battery would cost $120/kWh. Matching the Tesla retail cost of $155/kWh to $160/kWh yields a maximum possible gross profit of 25%. However, the ER&D costs could be much more expensive than the straightforward Volt retrofit costs; some Tesla models have over 8,000 individual cylindrical cells. By contrast, the Volt Ultium pack uses 96 cells with an easily packaged geometry that was defined earlier.

It will take significantly more time to put EV battery packs like Tesla's into production because of the complexity of managing thousands of individual cells. The production line would also be more complex, and therefore more expensive, than the uncomplicated Volt Ultium pack assembly sequencing. If the battery purchase price was $160/kWh, a possibility, there would be no profit potential. Combining this pricing uncertainty with the risk of attempting to compete directly with Tesla by offering the same kWh pack at the same price and there is a high probability (would you rather purchase a warrantied $12,000 battery pack from Tesla or from a start-up venture?) that an EV replacement battery pack program would have low sales volumes, or none, and not be profitable in the 2026 time frame. In other words, attempting to compete in the (non-Volt) EV battery replacement market in 2026 is risky due to unknown battery purchase costs, unknown ER&D and assembly line complexities, and not having a cost savings advantage over OEM replacement battery packs. This effort in 2026 has a high potential to result in losses.

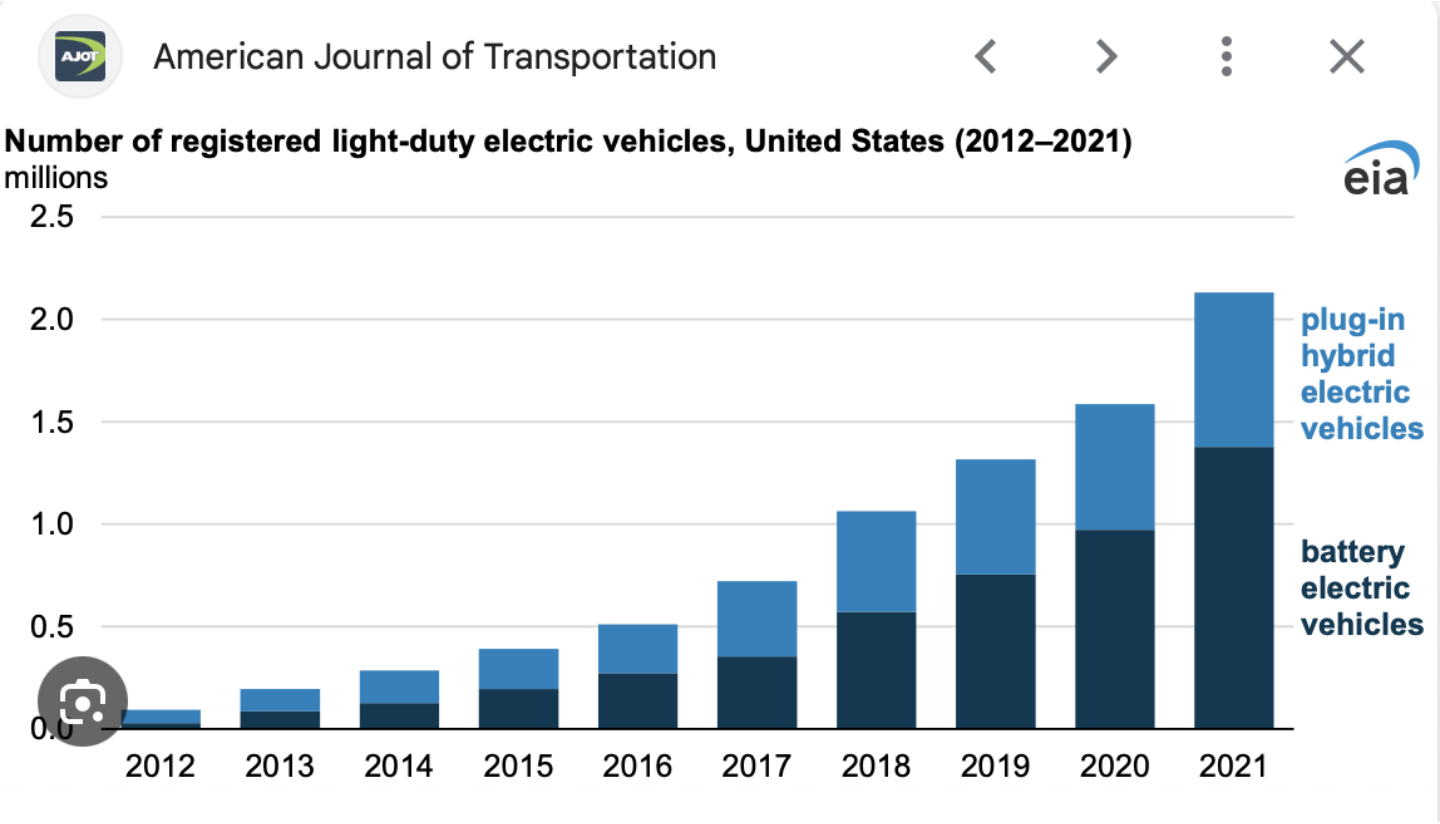
The cooling plate update requirement adds additional complexity. The original cooling tubes would need to be replaced when replacing an earlier, smaller cylindrical cell with a larger, higher capacity cell. Cylindrical cells have grown larger over the years; a 4695 cell will not fit in a cooling plate designed for an 18650 cell. The entire cooling circuit will need to be replaced with a cooling plate designed for a 4695 cell. The Tesla cooling tube packaging is shown below as is the internal tube shape that positions and retains the battery cells. Cylindrical cells will continue to evolve as they have done for the last decade so the cooling tube geometry would need to be updated as the cell geometry changed. The Tesla cooling tube, which partially wraps the cells, has been proven to be effective at cooling the battery pack.

These factors make it very challenging to develop a sound business case for offering a cylindrical cell retrofit battery pack in the 2026 time frame that would be profitable, given the ER&D, the tooling investments required and the highly competitive OEM pricing.



However, with ongoing improvements in battery specific energy and lower cost/kWh, there could be a substantial EV market opportunity by 2030 using cells with 500 – 600 Wh/kg specific energies that cost less than $50/kWh. There could still be over 200,000 EVs (50% of original sales), now with fifteen to twenty year old batteries having 1/3 to ½ the specific energy of a state of the art 2030 battery and that originally cost three times as much as 2030 batteries. The added time period also means EVs with 10 – 15 year old batteries become candidates for a battery pack upgrade, substantially increasing the market. There were an estimated 5.5 million EVs and hybrids built during 2015 - 2020 as EV production accelerated. This is an excellent opportunity, in a 2030 timeframe, to participate in a market that would be substantially larger than the current Volt market. Many of the EVs built in this period cost over $100,000, making investing in an extended range battery pack an economical way for owners to double

the range of their expensive EVs at a fraction of their original vehicle cost. At a conservative 1% (1 out of every 100 cars sold) penetration rate, that would be an additional 55,000 packs per annum just for this segment, roughly 25 times larger than the Volt market.



It is important to understand that dealer battery pack pricing reflects the cost of the original batteries that were installed in the original replacement packs. That is why a new Volt battery pack can cost as much as $25,000 from a dealer which is more than $1,000/kWh. The expectation is that dealer pricing in 2030, similar to dealer pricing today, will reflect ten to fifteen year old battery prices, not 2030 battery cell prices, making them just as uncompetitive in 2030 as new Volt production battery packs are now when compared to a re-engineered Volt pack using 2026 Ultium batteries.

Note: the higher volumes and the anticipated lack of OEM competition (i.e., the expectation that no OEM will be selling packs with new cells in original battery packs) in 2030, and the popularity of six figure EVs which make a $10k battery pack with double the original battery pack range an attractive proposition, provide more profit, making it possible to cover the ER&D and equipment costs much quicker in the 2030 time frame than in 2026.

2030 EV Battery Replacement Financial Estimates (Excludes 10 – 15 Year Old EV Replacement Annual Volume of 55,000 EVs @ 1% penetration)

Projected Volume (15 – 20 year old EVs): 200,000;
Penetration rate: 2%; 2 out of every 100 EV owners;
Projected sales: 4,000/year;
OEM internal price: $40/kWh;
OEM sell price: $60/kWh;
Retail sell price: $85/kWh;
Average original pack capacity: 75 kWh;

Average new pack capacity kWh (average): 150;
Average retail pack price @ 75 kWh and $85/kWh cell cost: $6,375;
Average retail pack price @ 150 kWh and $85/kWh sell price: $12,750;
Gross profit margin: 29%;
Net profit margin: 13%;
Gross sales (4,000 packs/year x $9,563 average) = $38,252,000;
Gross profit/year: $11,093,000/year @ 2% penetration;
Net profit/year: $4,972,760 @ 2% penetration.

Life Span of EVs

EV longevity is an essential component of a successful battery retrofit program. Electric vehicle owners confirm not only high mileage but also excellent reliability. There are many Volts and EVs for sale with over 200,000 miles on various websites and some with over 300,000 miles. The highest mileage Volt has traveled over 500,000 miles (called "Sparkie" in Volt forums). One Tesla graph shows the average life of a Tesla EV to be 250,000 miles. A 2014 Tesla Model S has covered more than 1,200,000 miles. This long life and reliability make a high mileage Volt or EV an attractive candidate for a battery upgrade that can, for a Volt, double its original range and could have a combined cost, for a used vehicle and an upgraded battery pack, of less than $15,000 total (140K mile Gen 1 Volts in excellent condition are for sale for under $5k at online sites today). 160k mile Model S Tesla's are currently on sale for under $6,000. The cost of an older used EV should be similarly inexpensive in five years. Because EVs typically have battery packs with 60 kWh to 100 kWh capacities, their battery cost, for a given $/kWh, will be significantly higher than the cost of the Volt's much lower capacity battery pack. A larger pack means that the absolute dollar savings, vs. a new replacement pack, will be substantially higher than the Volt's cost differential, accentuating the EV business case.

According to a report by IHS Markit, as of June 2021, the Chevrolet Volt had a 60% retention rate after 10 years, which means that 60% of the vehicles sold were still on the road. Note: the Volt 2021 retention study showed their retention rate is higher than the Corvette retention rate (Y car total retention is estimated at 50%). Link: https://www.gm-volt.com/threads/what-percentage-of-each-year-volt-still-on-road.345071/. The Corvette is Chevrolet's most iconic and valued model; the Volt's high retention rate is an indicator of a similar level of customer enthusiasm and loyalty.

The outstanding durability of EVs, and their low maintenance costs, a function of a motor with only one moving part, brakes that go 100,000+ miles because of regen, no transmission, no engine oil changes, and no filters, make it worthwhile to replace the primary long term wear item (outside of wiper blades and tires), the battery. Their reliability and durability, one OEM predicts 1,000,000 mile motor life, make older EVs a natural candidate for retrofitting advanced batteries that can potentially reduce the cost of a battery pack replacement while doubling their original range, making their driving distances competitive with new long range EVs at a fraction of their cost.

Income Potential for a Volt Battery Pack Using Ultium Cells

Two possible scenarios are presented below, one for a $120/kWh battery purchase price and one for a $160/kWh battery purchase price. The volumes are reduced for the higher purchase price cell. Each case generates more than $2M in annual net profits at relatively low penetration rates.

Total US market*: 157k x 60% (est'd Volts still on the road[1]) = 94,200 units

$200/kWh Sell Price Profit Analysis - $120 kWh Purchase Price

Estimated penetration at $7,320 sell price: 3%/year Gen 1 (88,000 x 60% = 52,800 Volts) and 1.5%/year Gen 2 (69,000 x 60% = 41,400 Volts). Gen 1 Ultium pack annual sales volume estimate at 3% penetration: 1,600/year; Gen 2 Ultium pack annual sales volume at 1.5% penetration: 600 units (values rounded to nearest 100 units). Lower volumes are used for the higher cost battery pack projections.

Gross Income: $16.1M (2,200 units x $7,320)

Estimated Gross Margin: 40% @ a 2026 purchase cost of $120 /kWh. (est'd GM internal cost is $80/kWh in 2026), $200/kWh sell price, and amortizing software and hardware development costs – assume a 20% net profit

Estimated Net Profit: $3,220,000 per annum

$250/kWh Sell Price Profit Analysis - $160 kWh Purchase Price

Estimated penetration at $9,150 sell price: 2%/year Gen 1 (88,000 x 60% = 52,800 Volts) and 1.0%/year Gen 2 (69,000 x 60% = 41,400 Volts). Gen 1 Ultium pack annual sales volume estimate at 2% penetration: 1,000/year; Gen 2 Ultium pack annual sales volume at 1.0% penetration: 400 units (values rounded to nearest 100 units).

Gross Income: $12.81M (1,400 units x $9,150)

Estimated Gross Margin: 36% @ a 2026 purchase cost of $160 /kWh. (est'd GM internal cost is $80/kWh in 2026), $250/kWh sell price, and amortizing software and hardware development costs – assume a net profit of 17%

Estimated Net Profit: $2,177,700 per annum

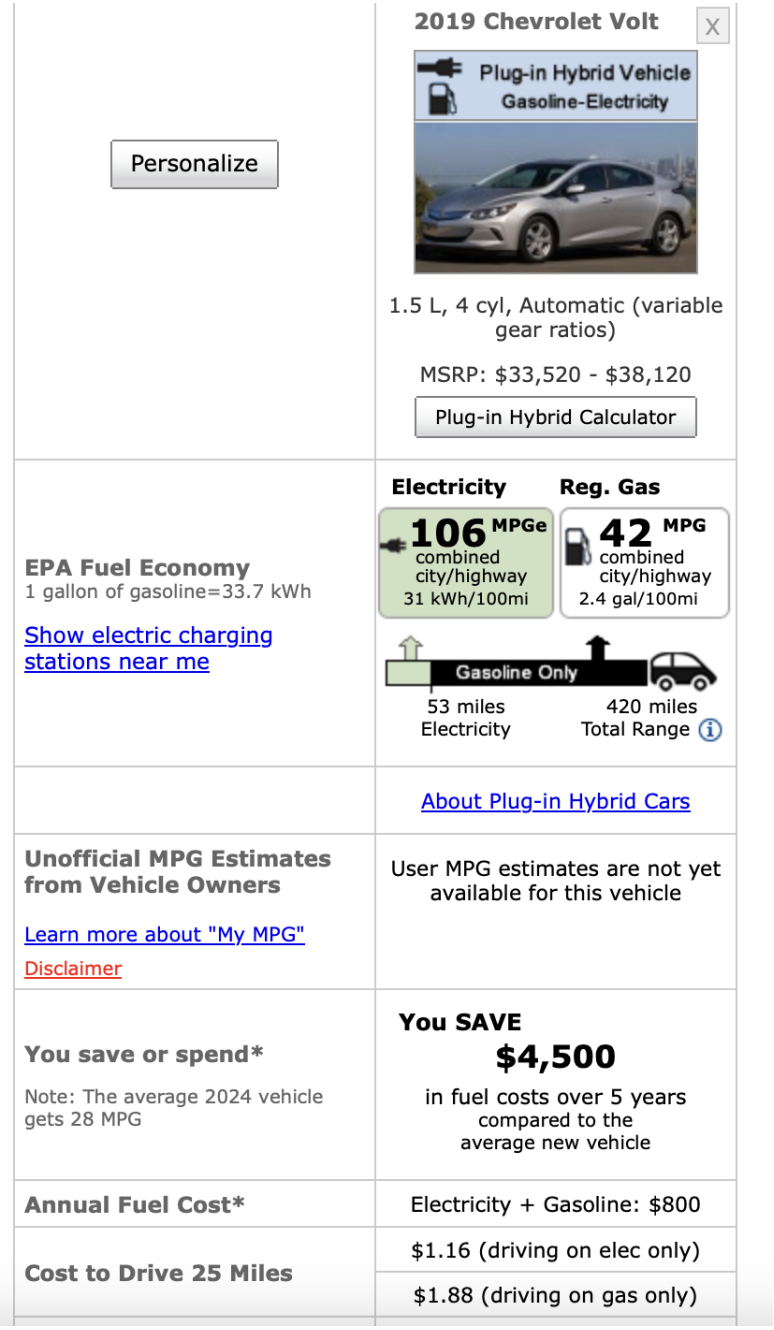
*U.S. Volt Production volumes (https://gmauthority.com/blog/gm/chevrolet/volt/chevrolet-volt-sales-numbers/) are: Gen 1: approx. 88k units; Gen 2 units: approx. 69k units. Canada sales: Gen 1: 3k units; Gen 2: 14k units.

The Value Proposition

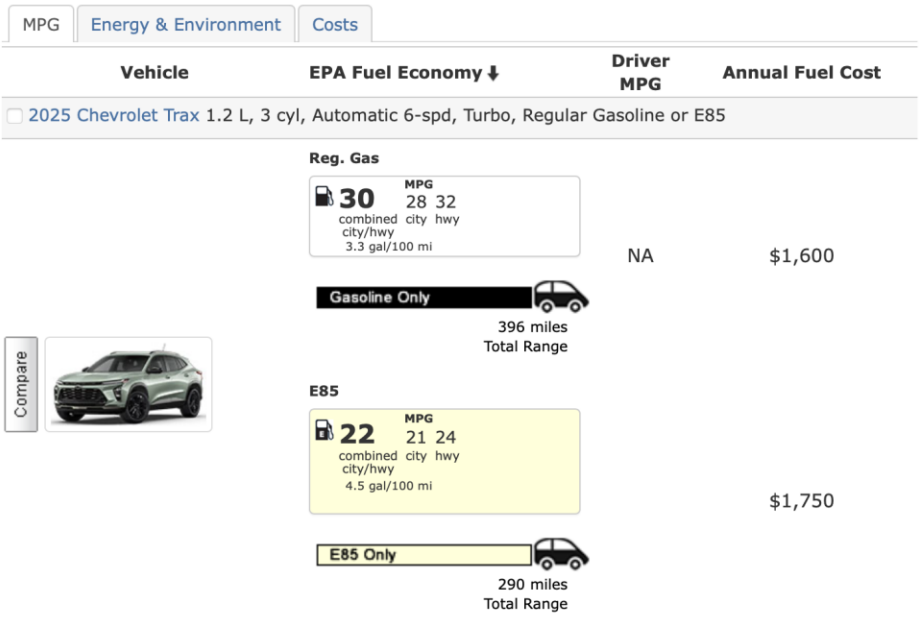
The cost over the expected 10 year (minimum) life of the new Ultium battery pack is about $700 to $900 per year. It is possible that some Volts fitted with this longer range Ultium based battery pack may never use gas again (except for the annual engine run ups that keep the fuel fresh), thereby lowering their $/mile cost to match pure electric vehicles. 15,000 miles at the Gen 2's 3.8 mile/kWh efficiency at $0.14/kWh ($0.06/kWh (MI off peak minimum rate) + $0.08/kWh distribution charge) will cost $442/year (15,000 miles/3.8 miles/kWh = 3,158 kWh x $0.14kWh = $442/year). Using the EPA 2019 Volt electric only estimate of $1.16/25 miles equates to an annual cost of $696 using electricity only. The EPA uses a higher rate for their electricity cost. The EPA estimates a 2019 Volt fuel savings at $900/year (a $4,500 savings over five years).

Compared to Chevrolet's most efficient small SUV, the Trax (1.2l, 3 cylinder, ICE), a retrofitted Volt will save a projected $1,158/year ($1,600 - $442) in Michigan using off peak minimum charge rates) or $904/year using the EPA value for $/kWh ($1600 - $696). Note that the $/kWh cost varies from state to state; a customer's $/kWh cost, and potential savings, could be higher or lower than these examples.

These fuel savings calculations show that they essentially offset the annualized Ultium battery cost. The fuel savings pay for the cost of the new Ultium battery pack over a ten year period.



Chevrolet's most efficient ICE vehicle, the Trax SUV, has an EPA estimated annual fuel cost of $1,600.



Business Development Scenarios

The Volt business case is compelling: sell a battery pack with state of the art cells with double the capacity of the original battery pack at $200/kWh or $250 kWh retail vs. almost $600/kWh for a refurbished battery pack with reduced capacity or as much as $1,300/kWh for a new replacement Volt battery pack with the original capacity. This makes this Volt project a win-win for both the seller and the purchaser. The projected annual profit from the Volt program, $2,000,000 to $3,000,000, is significant and could sustain a small engineering company and allow for development of other near term, high potential pouch/prismatic battery packages, as well as help cover development costs for future vehicle battery packs targeting 2030 batteries and an estimated 55,000 battery replacement candidates annually.

The EV business case is much different than the Volt business case. A penetration rate of 2% in 2030 means 4,000 conversions per year for 15 – 20 old EVs and could generate sales approaching $40,000,000 annually and a net profit of over $4,000,000 per year.

Additionally, even newer ten to fifteen year old cars, 2015 to 2020 models in 2030, could become a significant customer base by 2030. Owners of $100,000 and up ten year old EVs with 350 mile ranges that have degraded by 20% to 30% (to 245 mile to 280 mile ranges) may consider purchasing a battery pack that could potentially increase the range to 700 miles at a small fraction of the vehicle purchase price. The potential profits from 2015 - 2020 vehicles are not included in the above financial projections.

A business could gain experience from the low risk, lower volume Volt program and refine its production techniques to improve efficiency, i.e., improve the net profit margin, and gradually progress into EVs with pouch and prismatic cells, and then move into the higher volume, 2030 timeline programs for EVs, including cylindrical cell opportunities.

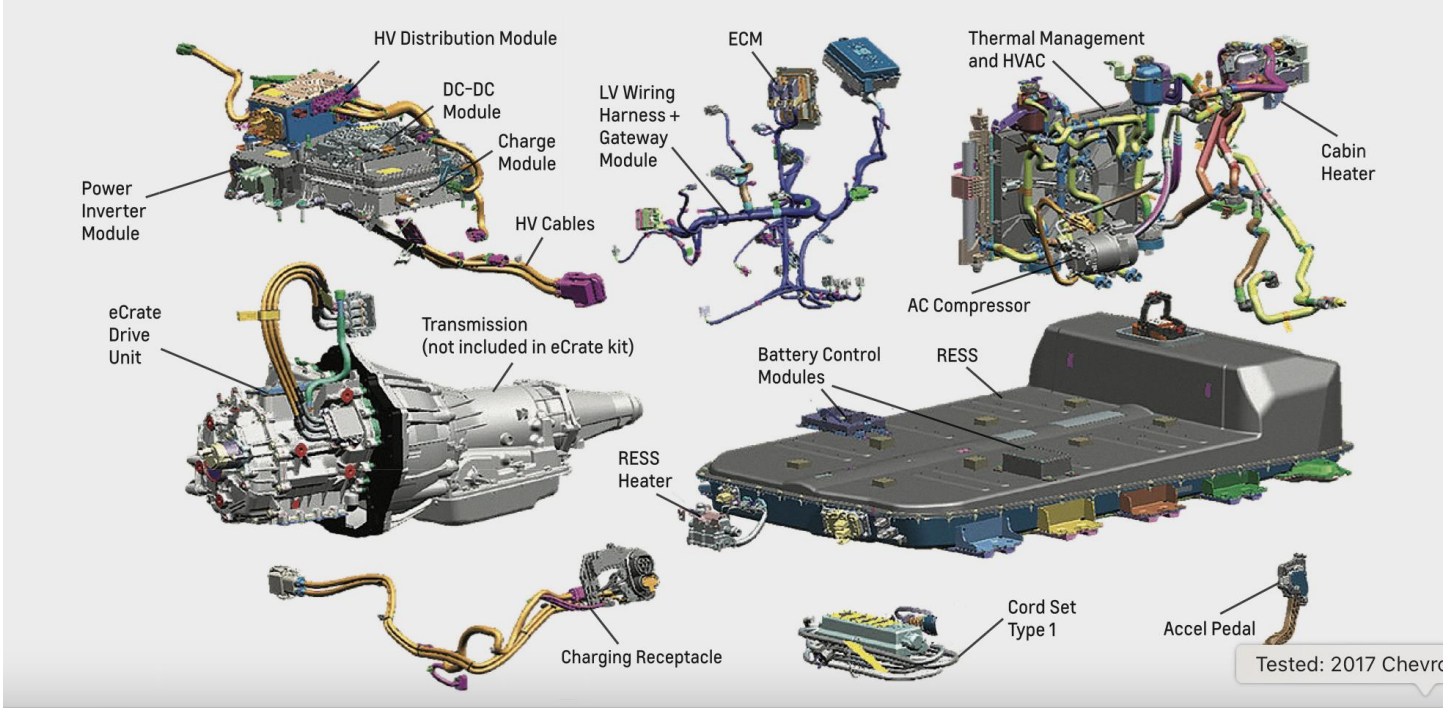
Targeted Aftermarket Manufacturers

Chevrolet Performance Parts contracted Lingenfelter Performance Engineering to engineer an aftermarket electric conversion kit for street rods; it is sold under the name eCrate through General

Motors. This is a comprehensive kit that includes a motor, an inverter, batteries, controllers, electronics, wiring, battery thermal management, air conditioning and a cabin heater.

Lingenfelter, as well as other qualified EV engineering centers, some named earlier, could potentially develop battery retrofit kits. Lingenfelter already has a financial relationship with GM, has demonstrated competence in this area, and is positioned to be able to negotiate a battery contract for Ultium cells with GM.

One purpose of this article is to see how many Volt owners would be interested in purchasing a $7k to $9k battery pack that would give Gen 1 owners an 81 mile range and Gen 2 owners a 105 mile range. If enough Volt owners request this, it could motivate an EV aftermarket engineering center to take on this project, one that is much simpler in scope than the complex LPE ground up eCrate kit.



Lingenfelter Performance Engineering eCrate Kit

Conclusion

This is a significant near-term opportunity that could: 1. Provide a substantial financial opportunity for an aftermarket EV engineering center to generate significant income and profits by fulfilling a market need for lower cost, longer range battery packs for Volts and for older EVs; 2. generate substantial positive press for GM (and help reduce lingering EV1 bitterness) by helping keep Volts, all examples of GM's engineering leadership, on the road; and 3. Make thousands of Chevrolet Volt owners very happy (over 90% of Gen 1 and Gen 2 volt owners said they would buy another Volt per numerous on-line sources but they can't – all Volts are ideal candidates for a battery pack retrofit). By substantially improving their range and battery longevity at an acceptable price and giving Volts new life with proven, GM engineered, state of the art, batteries, Volt owners could continue enjoying their Volts for at least another decade.

Thanks for your consideration.

Gregory E. Peterson (Gregg@asx.us, https://www.iflyasx.com)