



DIY Electric Car

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**DC forums: RegEdit
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Background

- 8 years IT
- 3 years IT Security
- 12 years Electronics & more
- FIRST Robotics
- Solar Power Station
- Solar Water Heater
- Rain Barrels
- Bike Generator
- Murphy Bed
- Workbench
- Voltswagon

Road Map

- EV History
- EV Acronyms
- EV Pros & Cons
- EV Uses
- EV Parts & Layout
- Open Source EV Hardware & Software
- EV Conversion Tools
- EV Conversion Steps

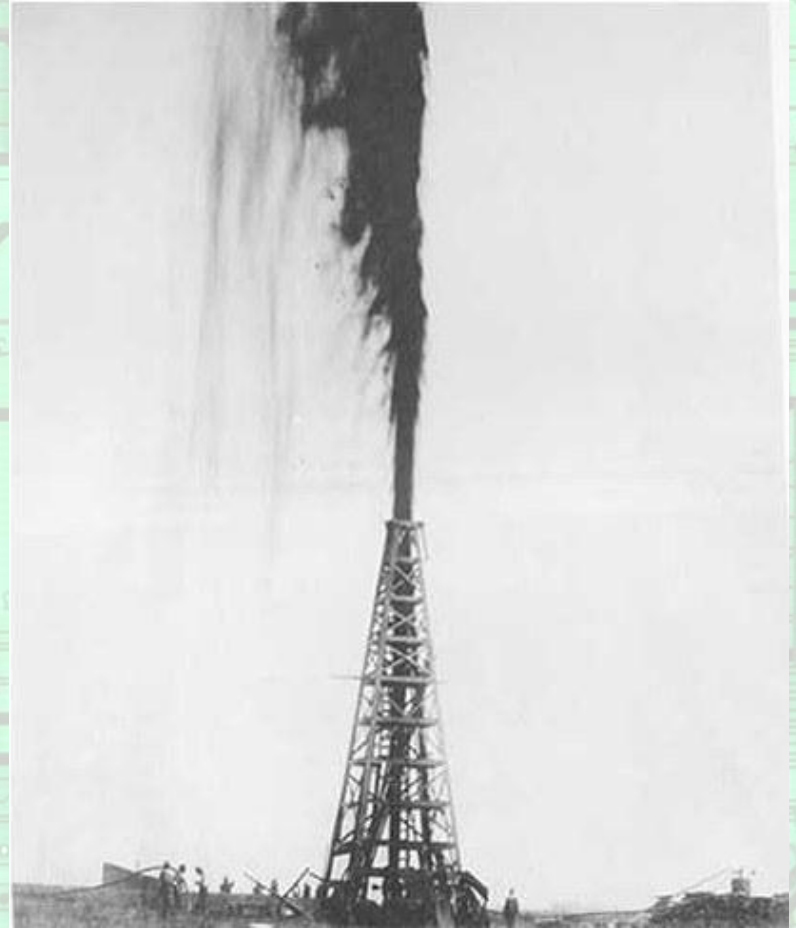
Car Wars (1835 - 1920)

- EVs predate ICE autos by 50 years
- 1889 – EV is first to break 100 km/h (60 mph) barrier
- EVs outsold ICE autos 10 to 1



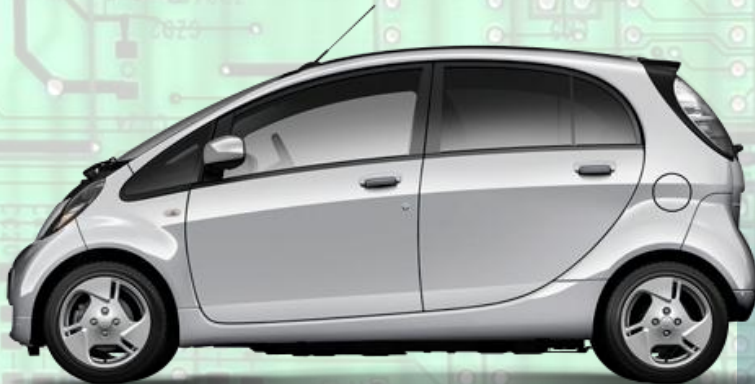
The ICE Strikes Back (1910 - 2012)

- Cheap oil
- Electricity still limited and expensive
- Growing rural population
- 1914 - Ford chooses gas-powered autos for motorized assembly line
- 1930 - Electric tram networks bought out and dismantled by GM and Big Oil



Return of the EV (1970 - 2012)

- 1970s – Air pollution concerns and OPEC embargo
- 1990 - 2003 – California Air Resources Board (CARB) mandates
- 2008 – Tesla
- 2010 – Nissan Leaf
- 2011 – iMiEV



EV Acronyms

- A – Amps
- AH – Amp Hours
- V – Volts
- w – Watts
- wH – Watt Hours
- wH/m – wH per mile
- MPGe – Miles per Gallon equivalent
- BEV – Battery Electric Vehicle
- NEV – Neighborhood EV
- PHEV – Plug-in Hybrid EV
- E-REV – Extended Range EV
- R-EEV – Range Extended EV

EV Pros

- Less Complexity
- Less Maintenance
- Efficiency
- Longevity
- Sustainability
- Energy Independence
- National Security
- Environmental



EV Cons

- Batteries
 - Upfront costs
 - Lower energy density
 - Weight
 - Range
- Charging Stations
 - Availability
 - Charge time

Misconceptions

- The grid can't take it
- Same pollution, moved to the plant
- More resources/pollution
- Lithium is scarce
- EVs are slow



EV Uses

- NEV
- Business
- Racing
- Commuting

NEV

- Golf Carts
- Security/Maintenance
- Grocery Getter
- Inexpensive
- Reduced regulations



Business

- High mileage yields quick ROI
- Predictable routes
- Low maintenance



Racing

- Peak torque from 0 RPM
- Wider power band requires less shifting



Commuting

- ~80% of US commutes are under 40 miles
- No energy wasted sitting in traffic
- Typical cost \leq \$0.02 / mile
- High efficiency (MPGe)
 - Energy: gasoline energy per gallon / Wh/m
 - $33.7 \text{ kWh} / 280 \text{ Wh/m} = 120 \text{ MPGe}$
 - Economic: gas price / electric rate / Wh/m
 - $\$3.33 \text{ gallon} / \$0.08/\text{kWh} / 280 \text{ Wh/m} = 149 \text{ MPGe}$

Voltswagon

Vehicle: 1974 Volkswagen Beetle

Range: 16-26 Miles

Speed: 70 MPH

Cost: \$6000

Time: 100 Hours



EV Parts List

Essentials

- Donor Vehicle
- Motor & Controller
- Shaft Coupler, Adapter Plate
- Batteries & Charger
- 12V Charger/DC-DC converter
- Battery/Motor cables & connectors
- Contactor(s) , Fuse(s)
- Voltmeter, Ammeter, Shunt
- Throttle

Conditionals

- Battery Management /Monitoring System (BMS)
- Brake/Suspension Upgrades
- SOC Gauge/monitor
- Precharge circuits

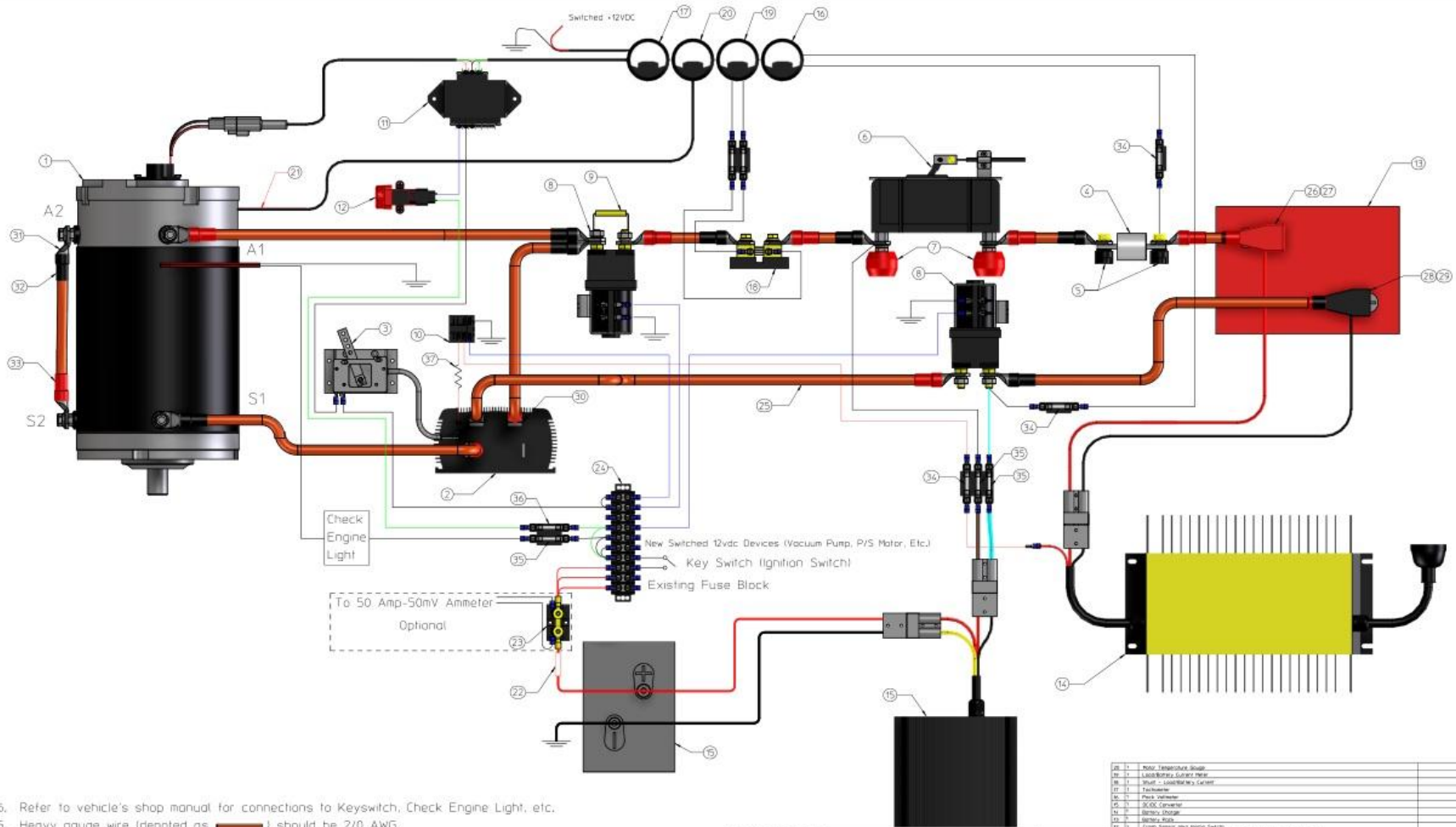
Recommended

- Circuit Breaker/Emergency disconnect
- Temperature sensor(s)
- Tachometer
- Inertia switch
- 12V AUX Battery
- Motor/controller cooling
- Battery Box(es) / Insulation
- AH Counter

Optionals

- AC
- Clutch
- Heater
- Low Rolling Resistance Tires
- Power Steering
- Solar Panel(s)

EV Layout



6. Refer to vehicle's shop manual for connections to Keyswitch, Check Engine Light, etc.
5. Heavy gauge wire (denoted as) should be 2/0 AWG.
4. Medium gauge wire (denoted as) should be 10 AWG minimum with 8 AWG preferred.
3. Light gauge wire (denoted as) should be 16 AWG.
2. Refer to documentation for installation and use details about each component (e.g. PakTrakr)!
1. High voltage cable and wire should have orange insulation, wrapped with orange electrical tape or enclosed in orange conduit.



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Part Number	Part Name	Part Number	Part Name	Part Number	Part Name
M-1	Washer - 3/8 Dia. x 1/4 Thick	SW-1	SW-1		
M-2	Fuse - 50 AMP Automotive	SW-2	SW-2		
M-3	Fuse - 50 AMP 250V Blue Wire	SW-3	SW-3		
M-4	Fuse - 50 AMP 250V Blue Wire	SW-4	SW-4		
M-5	1/2" Hex Bolt - 250V Blue Wire	SW-5	SW-5		
M-6	1/2" Hex Bolt - 250V Blue Wire	SW-6	SW-6		
M-7	1/2" Hex Bolt - 250V Blue Wire	SW-7	SW-7		
M-8	1/2" Hex Bolt - 250V Blue Wire	SW-8	SW-8		
M-9	1/2" Hex Bolt - 250V Blue Wire	SW-9	SW-9		
M-10	1/2" Hex Bolt - 250V Blue Wire	SW-10	SW-10		
M-11	1/2" Hex Bolt - 250V Blue Wire	SW-11	SW-11		
M-12	1/2" Hex Bolt - 250V Blue Wire	SW-12	SW-12		
M-13	1/2" Hex Bolt - 250V Blue Wire	SW-13	SW-13		
M-14	1/2" Hex Bolt - 250V Blue Wire	SW-14	SW-14		
M-15	1/2" Hex Bolt - 250V Blue Wire	SW-15	SW-15		
M-16	1/2" Hex Bolt - 250V Blue Wire	SW-16	SW-16		
M-17	1/2" Hex Bolt - 250V Blue Wire	SW-17	SW-17		
M-18	1/2" Hex Bolt - 250V Blue Wire	SW-18	SW-18		
M-19	1/2" Hex Bolt - 250V Blue Wire	SW-19	SW-19		
M-20	1/2" Hex Bolt - 250V Blue Wire	SW-20	SW-20		
M-21	1/2" Hex Bolt - 250V Blue Wire	SW-21	SW-21		
M-22	1/2" Hex Bolt - 250V Blue Wire	SW-22	SW-22		
M-23	1/2" Hex Bolt - 250V Blue Wire	SW-23	SW-23		
M-24	1/2" Hex Bolt - 250V Blue Wire	SW-24	SW-24		
M-25	1/2" Hex Bolt - 250V Blue Wire	SW-25	SW-25		
M-26	1/2" Hex Bolt - 250V Blue Wire	SW-26	SW-26		
M-27	1/2" Hex Bolt - 250V Blue Wire	SW-27	SW-27		
M-28	1/2" Hex Bolt - 250V Blue Wire	SW-28	SW-28		
M-29	1/2" Hex Bolt - 250V Blue Wire	SW-29	SW-29		
M-30	1/2" Hex Bolt - 250V Blue Wire	SW-30	SW-30		
M-31	1/2" Hex Bolt - 250V Blue Wire	SW-31	SW-31		
M-32	1/2" Hex Bolt - 250V Blue Wire	SW-32	SW-32		
M-33	1/2" Hex Bolt - 250V Blue Wire	SW-33	SW-33		
M-34	1/2" Hex Bolt - 250V Blue Wire	SW-34	SW-34		
M-35	1/2" Hex Bolt - 250V Blue Wire	SW-35	SW-35		
M-36	1/2" Hex Bolt - 250V Blue Wire	SW-36	SW-36		
M-37	1/2" Hex Bolt - 250V Blue Wire	SW-37	SW-37		
M-38	1/2" Hex Bolt - 250V Blue Wire	SW-38	SW-38		
M-39	1/2" Hex Bolt - 250V Blue Wire	SW-39	SW-39		
M-40	1/2" Hex Bolt - 250V Blue Wire	SW-40	SW-40		
M-41	1/2" Hex Bolt - 250V Blue Wire	SW-41	SW-41		
M-42	1/2" Hex Bolt - 250V Blue Wire	SW-42	SW-42		
M-43	1/2" Hex Bolt - 250V Blue Wire	SW-43	SW-43		
M-44	1/2" Hex Bolt - 250V Blue Wire	SW-44	SW-44		
M-45	1/2" Hex Bolt - 250V Blue Wire	SW-45	SW-45		
M-46	1/2" Hex Bolt - 250V Blue Wire	SW-46	SW-46		
M-47	1/2" Hex Bolt - 250V Blue Wire	SW-47	SW-47		
M-48	1/2" Hex Bolt - 250V Blue Wire	SW-48	SW-48		
M-49	1/2" Hex Bolt - 250V Blue Wire	SW-49	SW-49		
M-50	1/2" Hex Bolt - 250V Blue Wire	SW-50	SW-50		

KTA WIRING DIAGRAM KIT
 #EAG02/04/06, WashTech
 #EAG02/04/06, WashTech
 #EAG02/04/06, WashTech

Conversion Kits



Motor, Adapter Plate, Shaft Coupler



- 6.7" D&D ES-31B
- 72-144 V Series Wound DC
- Rated 12 HP, peak ~60 HP

Common Motor Options

- Warp



- Kostov

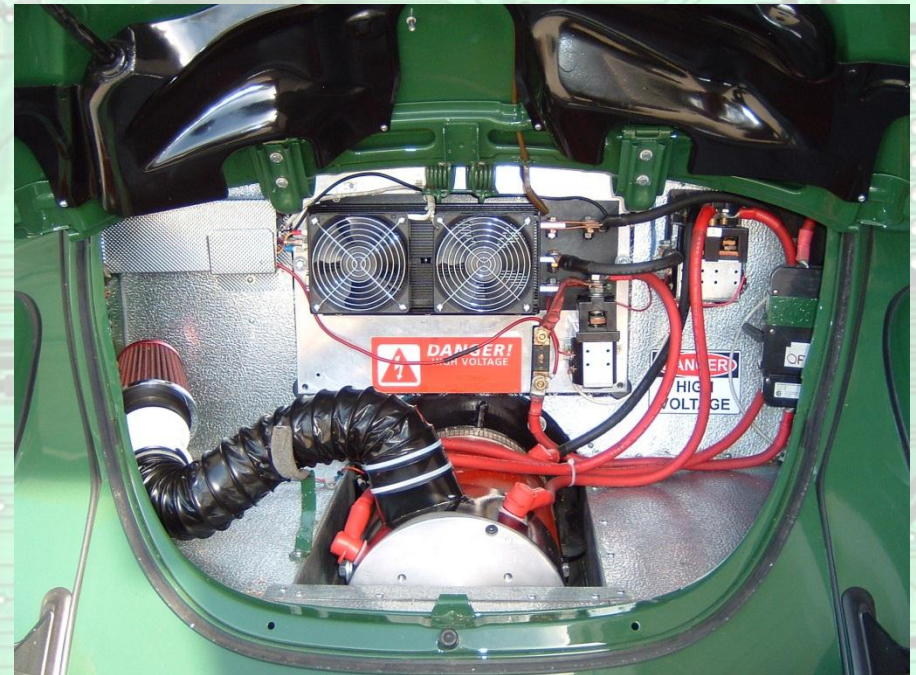
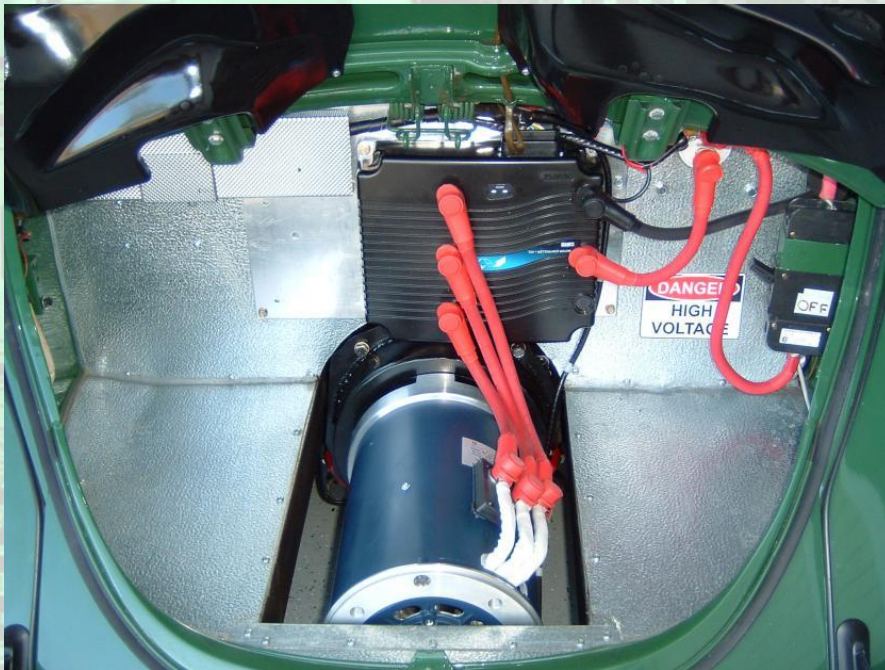


- Forklift

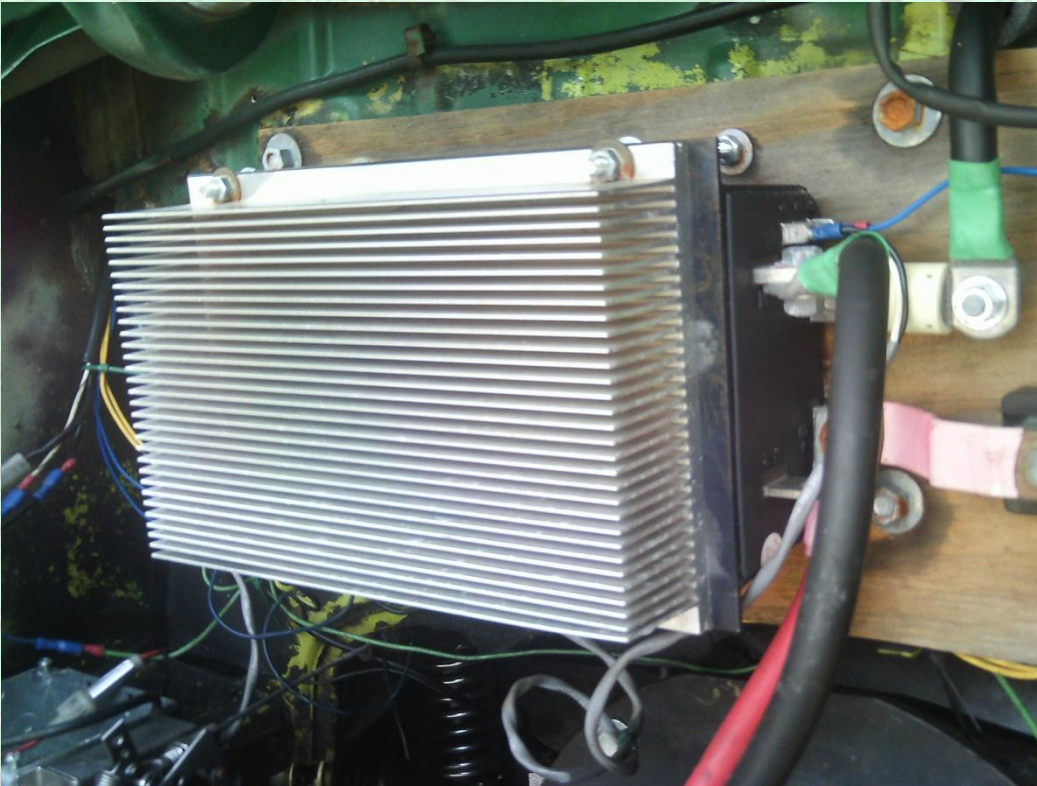


AC vs DC

- Easier Regen
- Runs cooler
- Even less maintenance
- Cheaper
- Greater selection
- Simpler



Motor Controller



- Curtis 1221C
- 120 V DC (nominal) 400 Amps Peak
- Aluminum finned heat sink

Motor Controller options

- Soliton



- Zilla



- Curtis



- Open ReVolt



Charger



Battery Pack

- 10 x 29DC Marine Deep Cycle Batteries
- 120 V
- 15 kWh
- 600 lbs



Battery Pack Calculations

- Range * wH/mile / 50% DOD / 60% Peukert
- $15 * 300 / .3 = 15 \text{ kWh}$
- Max range is 80% DOD

- Lithium
 - No Peukert
 - 70% DOD nominal
 - 80% DOD for max



Battery Options

Lead Acid



- Golf cart
- 6 V, 8 V
- 500-700 cycles



LiFePO4

- Prismatic
 - CALB, Sinopoly, Winston
- Cylindrical
 - Headway
- Pouch
 - A123
- 3.2 V
- 2000-5000 cycles

Lead vs Lithium(LiFePo4)

- Lower upfront cost
- Less sensitive
- No balancing necessary
- Easier to determine State of Charge (SOC)
- Light-weight
- Long cycle life
- High power output
- Less maintenance
- Flat discharge curve
- Better cold weather performance

To BMS, or not...

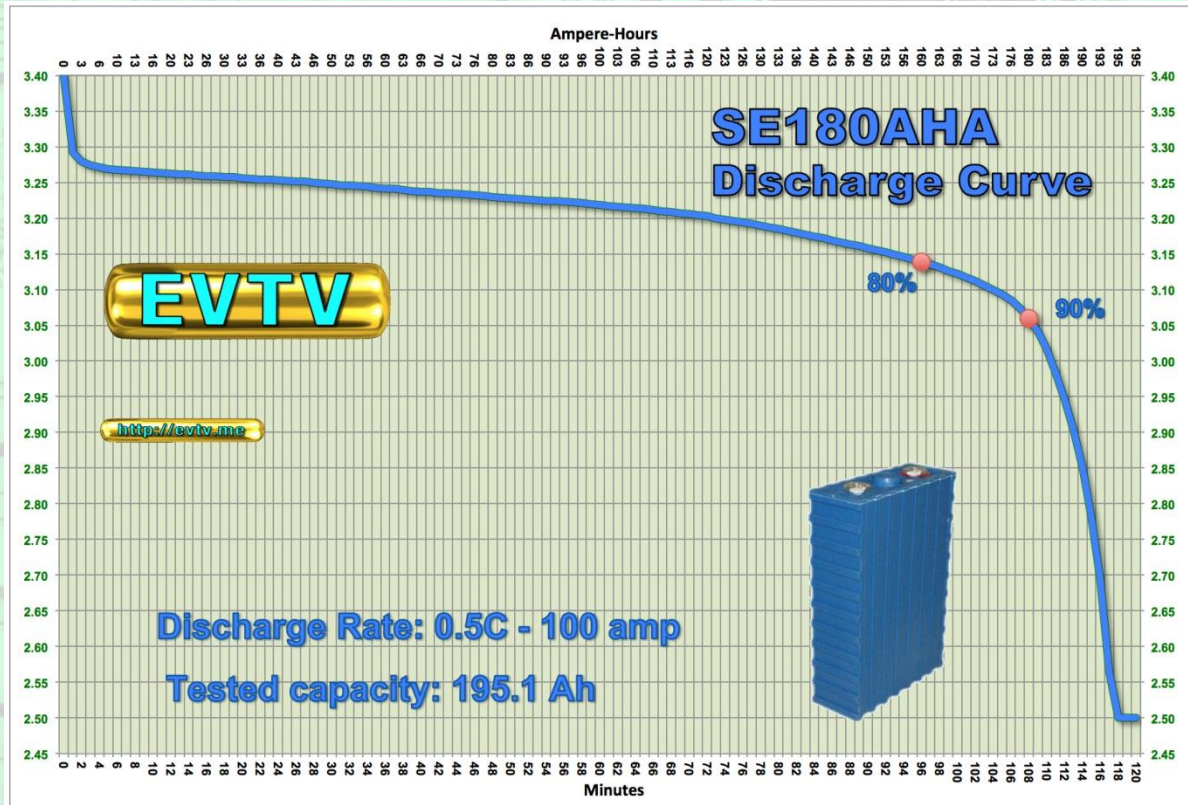
- Battery Management/Monitoring System required for some chemistries
- Active or Passive monitoring
- Distributed or Centralized
- Expensive /complicated
- Potential fire hazard



Balancing

- No two cells are identical
- Cells must be balanced to prevent damage
- Balancing matches cells at either top or bottom
- If overcharged, cell is damaged
- If overdischarged, cell can be pushed to reversal and destroyed

Discharge curve and Half-pack Bridge



- Monitor each half of pack
- Take action if imbalance passes threshold

Contactors, Precharge, & Coil Suppression

- Precharge Resistor
 - Prevents current surge
 - Preserves controller capacitors
 - Prolongs contact life
- Coil Suppression Diode
 - Prevents voltage spike
 - Usage depends on controller/contacter requirements



Accessories

- If needed, accessories may run off an auxiliary driveshaft, or be powered separately
 - Air conditioning
 - Power steering
 - Power Brakes



Open Source EV Hardware & Software

- Controller
- Charger
- Instrumentation
- Misc

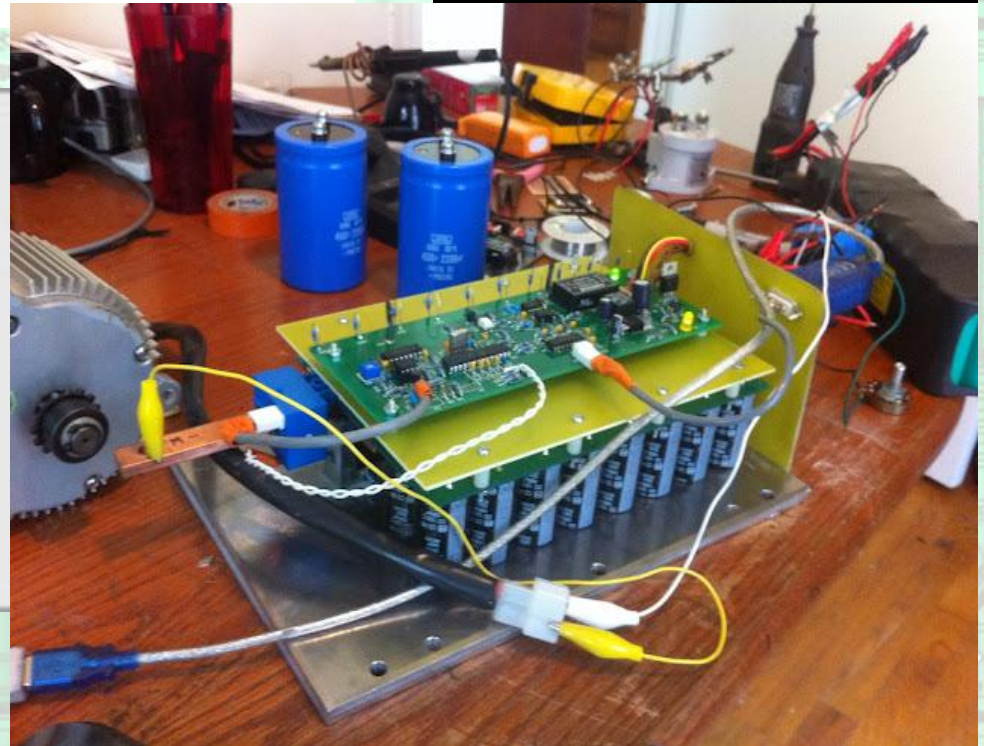


Open ReVolt projects

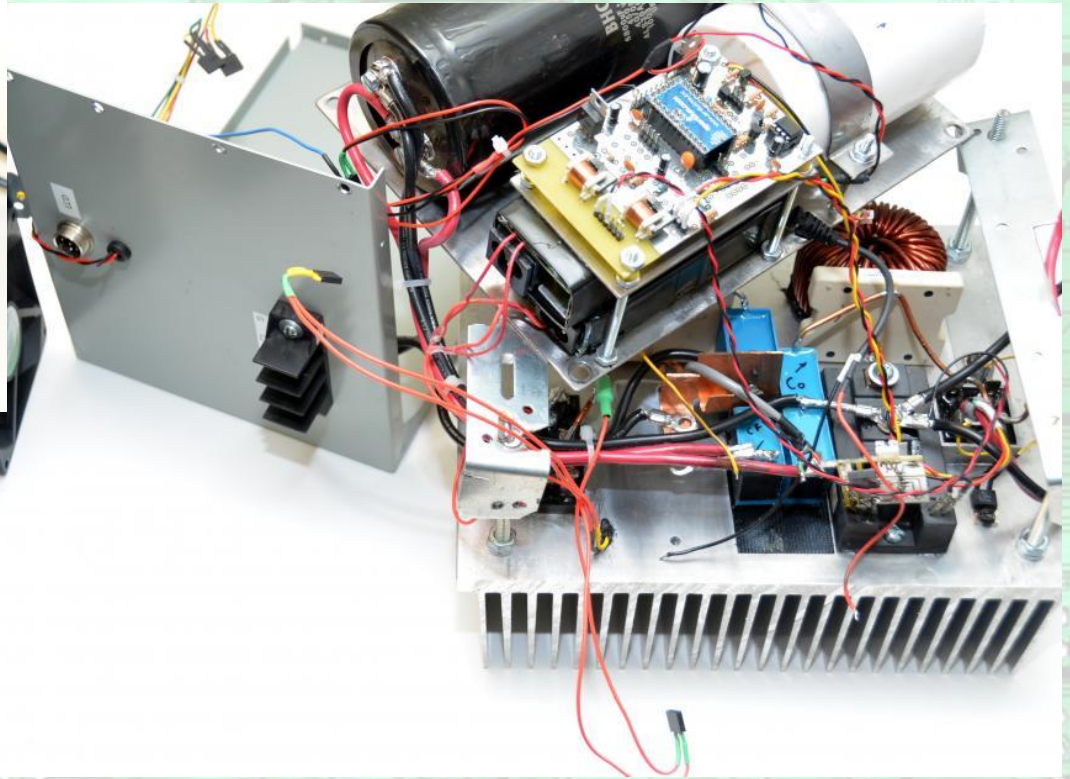
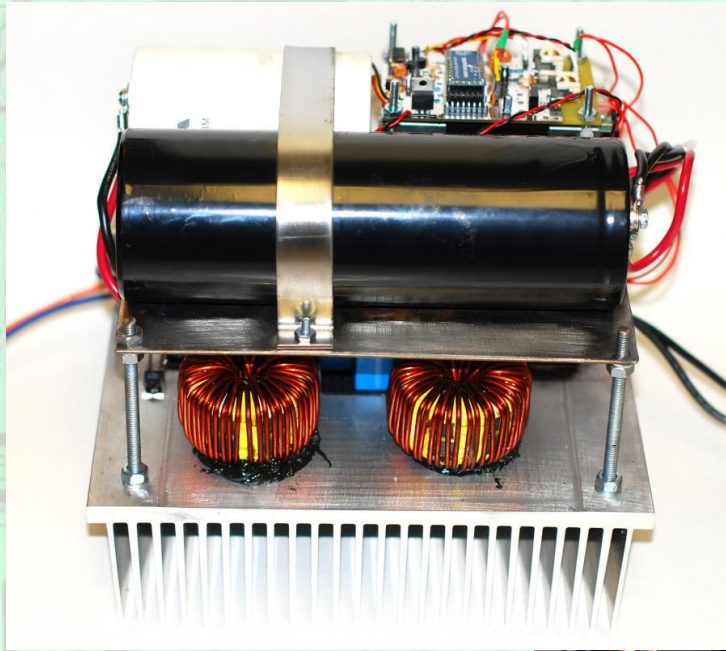
- > The Cougar EV Series 500 DC Motor Controller PCB & Mosfet Power PCB several versions are available on wiki.
- > The Cougar EV Series 1000 DC Motor Controller, Mosfet Power PCB, and Mosfet Driver PCB are available on wiki.
- > The preliminary EV SR Motor Controller PCB is on wiki, development is on going.
- > The preliminary EV AC Motor Controller PCB is on wiki, development is on going.
- >The preliminary EV DC LCD Instrumentation PCB - *Is now on wiki !!!*
- >The preliminary EV 6Kw DC Charger Controller PCB - *Was added to the wiki !!!*
- >The preliminary EV BMS Controller PCB - *Was added to the wiki !!!*

* Planned Future Open ReVolt projects *

- >The EV IGBT Driver PCB - *BG2A/VLA500 Interface - Coming Soon !!!*
- > The Uprising EV Series DC Motor Controller, and IGBT Driver PCB *Coming Soon !!!*



Electric Motor Werks 10kW 60A Open Source Charger



EV Dashboard



EV Conversion Tools

Essentials

- Shop manual for donor vehicle
- 2+ ton trolley jack (high clearance preferred)
- 2+ ton adjustable jack stands
- Creeper
- Sockets, Wrenches, Screwdrivers, Pliers
- Angle Grinder
- Handheld drill
- Digital Volt Meter (DVM)
- Wire strippers and crimpers
- Cable cutters and crimper
- Shop light
- Rotary tool
- Measuring Tapes

Carry-On

- Digital Volt Meter (DVM)
- Jumper cable
- Commonly used Sockets, Screwdrivers

Recommended

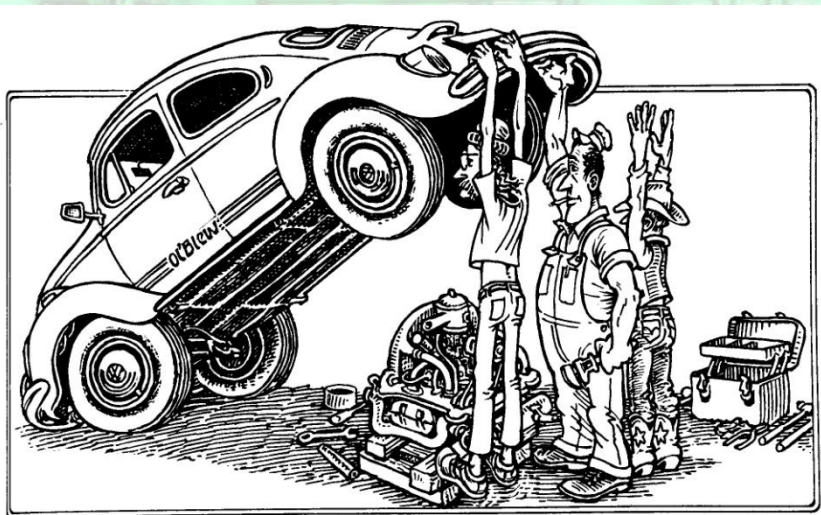
- Electrical Tape
- Engine hoist or transmission jack
- Clamp On Ammeter
- Drill press
- Air compressor
- Rhino Ramps
- Welding Equipment
- Safety goggles or glasses
- Latex (or similar) gloves
- Soldering Iron
- Zip Ties
- Vise

Optional

- Workbench
- Box cutter, Jigsaw, Cut-off saw, Hacksaw
- Hammer, Pry Bar
- Heat gun or torch

EV Conversion Steps

- Build Requirements
- Explore the Possibilities
- Find a Donor
- De-ICE
- Eliminate Waste
- Install EV Components
 - Motor
 - Controller
 - Batteries
 - Charger
 - Accessories
- Hit the road!
- Keep on Hacking



Build Requirements

- Motivations?
- Maximize utility
- How far?
- How fast?
- Budget?
- Skills?
- Reality check



Keep it Legal

- Each state\country is different
- Some require inspections
- Some have strict requirements
- Some do not allow typical conversions
- Some don't know what an EV is

Explore the Possibilities EV Album

EV ALBUM

SEARCH

YOUR EV

EV RESOURCES

CONTACT

THE ELECTRIC VEHICLE **PHOTO ALBUM**

CURRENT TOTAL 3725 VEHICLES



[Doug Johnson's](#)
[1997 Ford Ranger XLT](#)
Updated: 06/22/2012



[John W Mitchell's](#)
[1997 Saturn SC](#)
Updated: 06/23/2012



[Martin Winlow's](#)
[2008 Vectrix VX-1](#)
Updated: 06/18/2012



[Bill Bates's](#)
[2001 Nevco Gizmo](#)
Updated: 07/07/2012



[thingstodo's](#)
[1991 Chevrolet S-10](#)
Updated: 06/16/2012



[Pranav Bheda's](#)
[1972 Volkswagen Super Beetle](#)
Updated: 06/15/2012



[Jarkko Santala's](#)
[1987 Kawasaki GPX750R](#)
Updated: 07/08/2012



[Bruce Westlake's](#)
[2011 Th!nk City](#)
Updated: 06/12/2012

Find a Donor

- Fun to drive
- Good working order (except engine)
- Aerodynamic
- Lightweight
- Cargo space

De-ICE

- Remove the engine
 - Find buyer first!
 - Jack up 2-3 feet for bottom removal
 - Engine hoist for top removal
- Drain and remove gas tank, radiator, starter, alternator, and other obsolete stuff

Eliminate Waste

- Less weight and less power draw = more range
- May be able to remove or replace non-essentials
 - Swap Fix-A-Flat for spare tire
 - Convert power steering and brakes to manual

Install EV Components

- Attach adapter plate and coupler to motor
- Install motor and controller
- Build/install battery boxes
- Install batteries and charger
- Install instruments, wiring, accessories, etc

Where to charge



- 110 V AC
 - 20 Amps

8 miles charge/hour



- 220 V outlet
 - 50 Amps

44 miles charge/hour



- J1776-2009
 - Level 1 120 V AC
 - Level 2 240 V AC
 - 80 Amps

76 miles charge/hour



- CHAdeMO
 - Level 3 500V
 - 125 Amps

250 miles charge/hour

Hit the road!



Sounds Great, But...

- Perpetual Motion
- Hydrogen
- Supercapacitors
- Hub Motors
- DIY Hybrid
- Solar

Keep on Hacking

WARNING: EV Conversions are a very addictive/obsessive hobby. The only way to 'finish' a conversion is to start another.



EV Resources

- Vendors Used
 - Wilderness EV
 - KTA Services, Inc.
 - Cloud Electric
 - Sam's Club
 - Calib Power
 - ebay
 - Lightobject
 - Chennic



- Additional Resources - chargedevs.com/Build-an-EV

Motor:	\$1200
Controller:	\$1000
Batteries:	\$800
Charger:	\$600
Adapter/Coupler:	\$500
Misc:	\$800



No longer being OPECXXON's Bitch...Priceless