Allis-Chalmers G
Electric tractor conversion

How this project came about: In March of 2007 I called Steve Heckeroth, a long time electric vehicle and solar advocate, to see if he could bring one of his electric tractors from northern California to the Advanced Vehicle Innovations (AVI) Summit in Wenatchee, WA in May. As a member of the AVI group, and based in an agricultural economy area, I wanted to exhibit a hybrid, plug-in hybrid, or electric agricultural vehicle.

Steve suggested we convert a tractor locally instead, and referred me to the Flying Beet web site (www.flyingbeet.com/electricg), a community supported agriculture (CSA) farm in New York. The folks at Flying Beet had converted an Allis-Chalmers G gas engine tractor to electric drive and received a USDA grant to refine the process and publicize it on the web. Much of the success of our project is due to their pioneering the design and installation of the conversion components. Anyone interested in doing a G electric conversion should start by studying their instructions.

I checked out the web site and wondered if Guy Evans and Rachel Airmet at Sunshine Organics, a CSA in Chelan, WA might be interested in an electric G. Turns out they were already looking for a G because it is so well suited for row crop cultivation, and they readily agreed to pursue the electric conversion.

I researched the cost of components and gave them an estimate. They found two Gs and arranged funding to purchase the tractors and the conversion components.

The AVI Tech Group, of which I am a member, agreed to do the conversion with volunteer labor, and Wenatchee Valley College volunteered their auto shop for work space.

Pre-work: Rachel purchased the two Allis-Chalmers G tractors and transported them to Chelan. One was stripped of the gas components, checked for mechanical safety, sandblasted and painted.

The “donor” G tractor, with the gas engine already gone. Note the second G in the background with the gas engine still intact.

I procured the electric conversion kit, batteries, motor, and other components. I mocked up and pre-assembled the parts as much as possible, mainly to be sure we had everything we needed, that they would fit as expected, and to reduce the time needed for the conversion workshop.

The mocked up battery bank in my garage, with green assembled motor plate and motor cover nearby.

What was done at the conversion workshop:

The eight AVI Tech Group members present were divided into groups.

Briefing the AVI Tech Group volunteers, while G owner, Rachel, observes patiently.

Group 1 installed the motor mounting plate on the tractor bell housing, mounted the motor controller on the motor plate, and then wired the controller to the motor. The motor cover was installed after testing the entire conversion.

Motor plate installation.

Group 2 installed the battery box rack and the battery box floor with pre assembled components (main circuit breaker, contactor, DC/DC converter, 12v battery hold downs, 12v load center, and ammeter shunt), then added the batteries, installed main battery hold downs, and wired everything inside the box together (series wired the 48v battery bank, wired the 12v battery to the 48v/12v DC/DC converter and 12v load center). They then installed the potbox on the underneath side of the battery box and connected the throttle rod from the original tractor throttle to the potbox. The battery box lid was installed after testing.

Battery rack and battery bank installation.

Group 3 installed the instrument cluster and headlight on the tractor steering column support and wired the headlight to the headlight switch.


Instrument cluster installation.

Then everyone worked on wiring the components together. This included:

- the motor circuit from the battery box contactor to the controller, and the motor to the battery shunt.
- the ignition switch to the 48v battery, potbox foot switch, contactor coil, and controller.
- the ammeter to the 48v battery and shunt.
- the state of charge meter to the 48v battery.
- the headlight switch to the 12v load center.
- installing wire ties and wire wrap as needed.
- painting Vaseline on the 48v and 12v battery terminals, after all connections were made, to deter corrosion.

Things we did differently than the Flying Beet instructions:

- Based on my experience with renewable energy systems, we added a main circuit breaker and fuses, and a 48v/12v common chassis ground, to insure any short circuit would be safely handled by a tripped breaker or blown fuse. I also increased the cable size used in the 48v circuit to comply with NEC ampacity standards. It’s interesting that electric vehicles routinely use smaller wire than the NEC allows for renewable energy systems of equal ampacity.

- We added a 48v state of charge “fuel” gauge and ammeter to help the operator make decisions to extend time between battery charges and extend battery life. The ammeter helps chose the right gear to do the work using the least amps of power, extending hours of use between charges. The state of charge meter allows the operator to recharge the battery bank before it discharges to the point of decreasing battery pack life.

- A keyed “ignition” switch was installed to prevent unauthorized use, since this tractor will be displayed at public venues.

- I consulted with experienced electric vehicle enthusiasts and incorporated their suggestions to use a DC/DC converter and auxiliary 12v battery for lights and other 12v loads, instead of tapping off one of the four 12v traction batteries. Although 12v loads may be small and infrequently used, this insures the main batteries remain balanced and last as long as possible, and also means lights will work if something happens to the traction battery bank.

- We were unable to get an all weather contactor, as recommended by Flying Beet, in a reasonable period of time so we mounted a standard contactor inside the battery box to provide weather protection.

- Based on a wiring diagram for electric vehicles provided by Electric Vehicles USA, we added diodes and resistors in the ignition/contactor loop. These reduce the electrical shock of switching large loads on and off. This diagram also showed different terminals to use for connecting to the electric motor, than the Flying Beet web site. We followed the diagram from EV USA for motor wiring, assuming we’d change if there were problems, but it worked fine.

- We added a six circuit 12vDC load center to have a compact location for 12v load fuses. Circuits are currently used for the headlight and a screw drive implement bar lifter.

- We added quick connects, with dust covers, for the battery charger connection on the underneath, rear side, of the battery box. This insures a quick and safe attachment method to charge the 48v battery bank, without removing the battery box cover, and without concerns for reverse polarity connection, since the connectors can only be attached one way. The on-board connector is secured to the battery box, and the battery charger cable will be secured to the garage. If an operator forgets to disconnect before driving off, the connector will disengage without serious damage. An interlock, that prevents operation while connected to the charger, would be preferred, but is more complicated.

- We used a wall mounted Iota 48v charger with Smart Controller to provide a three stage charging cycle. This insures the best charge and longest life for the battery pack.

- We custom welded a battery rack from angle iron to keep the traction batteries as low and as far forward over the axle as possible, while still not interfering with the spring motion of the seat. We were a bit concerned that, with 320 lbs of traction batteries, the tractor might be heavy in the back and tend to do “wheelies”. But, even without a driver or implement bar, it still takes about 100 lbs of effort to lift the front.

- We built a vented plywood battery box cover to protect the batteries and other components from the weather, dust, and rocks and sticks that tractors tend to kick up. The battery box cover also prevents accidental shorts, which could be dangerous and costly.

- We pre-painted components to insure longest life, and it looks good!

Problems we encountered and how we solved them:

- While disassembling the donor G, it was noted that the brake return springs attached to the radiator bracket, which was no longer needed and was being removed. When we transported the unconverted G to the conversion workshop, we temporarily attached the brake return springs to bolt holes on the upper rear of the bell housing so the brakes worked properly. During the conversion, we attached the springs to the rear battery rack supports that are bolted into the original upper rear implement attachment bolt holes.

- Installing the battery rack revealed the right rear support would not fit flush with the implement mounting hole because a welded nut on the back of the motor mount plate, which wasn't in place when the battery rack was designed and test fitted, interfered. We notched the battery rack support to clear the nut.

- When connecting the original hand throttle to the pot box, we were concerned that going beyond the throttle notches might damage the pot box arm, or re-close the pot box foot switch by going beyond throttle "off". We installed two bolts for hand throttle stops, to limit throttle travel and any potential heavy handed damage to the pot box.

- When we first turned on the keyed ignition switch, we blew a fuse. Hmm... There was no installation instructions with the contactor. I assumed the two tabs on one side were one end of the coil circuit, and the two tab on the other side were the other end of the circuit, and wired the contactor "ignition" circuit accordingly. This was wrong. The two tabs closest to the 48v contacts, opposite one another, are one end of the circuit, and the farthest two tabs opposite one another are the other end of the circuit. I also assumed the contactor coil was activated by 12 volts. This was also wrong, the coil requires 48v to close the contacts. We rewired the "ignition" switch for 48 volts and rewired the contactor, and both worked!

- But, the motor did not spin when the throttle was advanced. Hmm... Tracing the wiring to the controller revealed the 48v "ignition" lead from the pot box foot switch had been mistakenly connected to the "reverse" tab on the controller. It was moved to the correct tab and the motor turned!

- Testing the headlight blew the headlight fuse. Thank goodness for fuses! Troubleshooting revealed the headlight ground wire, which had been installed to insure a better ground to the headlight than just chassis ground, had been installed on the positive lead to the light - a dead short, and the headlight switch had been installed upside down, so it was "on" when the toggle switch was down. This resulted in an immediate blown fuse. These problems were corrected and the headlight worked properly.

- When everything was operational, we installed wire wrap to bundle wiring in the battery box and to the instrument cluster, installed the motor cover and battery box cover. While installing the battery box cover, we realized the battery rack was sloping down slightly on each end. Looking at earlier photos of the installation, we realized it was bent from the start. I think we may have bent it after welding it, when my neighbor and I stood on the ends to check its strength (it held us both).

The completed conversion.

The first test drive: Rachel, the owner and principal operator, had the honor of the first test drive. She adapted quickly to not having a clutch, using the throttle and brake to slow and stop. She tested forward and reverse and immediately commented on how quiet the tractor operated. She backed the tractor onto the tilt bed trailer, and commented how smooth it was crawling up the tilt bed. Love that low end electric motor torque!

The first test drive!

Things we'd do differently:

We'd make the battery box an inch or two wider and longer to give more clearance inside for wire bundles, hold downs, etc.

We'd mount the forward battery rack supports on the inside of the original gas tank support tabs, which are on the axle housing outboard of the brakes. When the brakes need to be serviced the rack could then be braced in place, the forward supports disconnected, and the axles removed to access the brakes, all without having to remove the battery rack. We realized our forward rack supports are on the outside of the gas tank tabs. We'll have to rotate the heavy battery rack up enough to clear the gas tank tabs in order to remove the axles and access the brakes - or dismantle the whole battery rack. Ugh!

We would install a second six circuit DC load center for 48v loads to avoid the multiple terminals connected to 48v positive and negative (ignition, state of charge meter, ammeter, battery charger.)

The conversion workshop took about nine hours. Much longer than expected, but everyone took time to do the most professional job possible. Based on what we learned, the next conversion will go much faster.

Overall, this was a fun project. I learned a lot about electric vehicle conversion, with the help of many others. The project has stirred a lot of interest in our area, where agriculture is still the primary economic base, and inexpensive hydro power makes electric vehicles economically attractive.

Resources:

Randy Brooks, Brooks Solar, Inc. 509-682-9646, www.BrooksSolar.com, Randy@BrooksSolar.com

Steve Heckeroth, steve@renewables.com

Flying Beet, original conversion details, www.flyingbeet.com/electricg

Niekamp Tool Co, Allis-Chalmers G electric conversion kit, 800-354-3569

Electric Vehicles USA, EV components, www.electricvehiclesusa.com

Allied Battery, Trojan deep cycle batteries, 509-886-4108

Allied Electronics, diodes, resistor, quick connects, www.alliedelec.com

Wiring diagram