ENERGY FOR OFF-GRID CAMPING
INTRODUCTION

➤ Mel & Liza Hendricks

➤ Camper: 2012 Aliner Expedition
  ➤ Lightweight - 2500 lbs loaded
  ➤ Insulated - 1” foam

➤ Folding:
  ➤ Less headwind resistance
  ➤ Less crosswind
  ➤ Fits in garage

➤ Queen size bed, dinette, bath/shower, heater, stove, sink, fridge+freezer, microwave, air conditioning
CAMPING ENVIRONMENT

➤ Many campground providers

➤ Most provide toilets, water source, dump

➤ Electric and water costs included in daily costs (not measured)

➤ Three main types of campsite utilities.

➤ 50A

➤ 30A

➤ No campsite utilities (usually more scenic, spread out, center of park)

➤ Add’l services often available

➤ Sewer connections, showers, store, pool
GOAL: COMFORTABLE EXTENDED CAMPING IN BEAUTIFUL AREAS

➤ Extended dry camping National Parks, National Forests, State and City Parks
  ➤ Close to sights, activities, attractions (less driving)
  ➤ Scenic campsites near trails, sights, activities, attractions
  ➤ Uncrowded, quiet

➤ Minimum energy oversight time

➤ Our campsites normally:
  ➤ Are inexpensive ($5-$25/night)
  ➤ Are shaded (trees, mountains)
  ➤ Do not have campsite electric or water
TYPICAL CAMPSITES:
OEM ENERGY CONFIGURATION

**Recharge Power**
- Grid, 120vac
- Generator, 120vac
- Auto Alternator+Inverter, 120vac
- Solar Generator
- Auto Alternator+7-pin
- Auto Alternator+Cables
- Re-Fill Tanks
- Swap tanks

**Charging+Storage**
- LP (Propane), 20#
- Converter
- Power Supply + Charger
- Regulator
- Battery, Lead Acid: 12vdc, 100ah
- 12-13.9vdc

**Loads (Red=High)**
- LP Fridge, cooling
- LP Space Htr, 60% efficient
- LP Water Htr
- LP Stove - Cooking, Coffee
- 120vac, Space heater
- 120vac, Air conditioner
- 120vac, Coffee pot
- 120vac, Computer charging
- 12vdc, Lighting
- 12vdc, Exhaust fan (Fantastic)
- 12vdc, White water pump
- 12vdc, Water Htr, Controls
- 12vdc, Lighter power plugs
- 12vdc, Toilet water pump
- 12vdc, LP/CO sensor/alarm
- 12vdc, LP Fridge controls

**Breakers**
- 120vac, Space heater:
- 430,270 Btu/tank:
- 4,095 Btu/Battery
OEM ENERGY CONFIGURATION

**Recharge Power**
- Grid, 120vac
- Generator, 120vac
- Auto Alternator + Inverter, 120vac
- Solar Generator
- Auto Alternator + 7-pin
- Auto Alternator + Cables
- Re-Fill Tanks
- Swap tanks

**Charging + Storage**
- Regulator
- LP (Propane), 20#
- Converter
- Power Supply + Charger
- Battery, Lead Acid 12vdc, 100ah
- 12-13.9vdc
- 4,095 Btu/Battery
- Reduced recharge time = Less fuel, noise, oversight

**Loads** (Red=High)
- LP Fridge, cooling Reduced LP
- LP Space Htr, 60% efficient
- LP Water Htr
- LP Stove - Cooking, Coffee
- 3

**Tubing**
- 430,270 Btu/tank
- 120vac, Space heater
- 4,095 Btu/Battery

**Breakers**
- 120vac, Air conditioner
- 120vac, Coffee pot
- 120vac, Computer charging
- Reduced electric

**Fuses**
- 12vdc, Lighting
- 12vdc, Exhaust fan (Fantastic)
- 12vdc, White water pump
- 12vdc, Water Htr, Controls
- 12vdc, Lighter power plugs
- 12vdc, Toilet water pump
- 12vdc, LP/CO sensor/alarm
- 12vdc, LP Fridge controls
- Reduced electric

**Reduced electric**

**Reduced LP**

**Reduced Oversight Time**

**Reduced LP Space Htr, 60% efficient**
TRIP REPORT AFTER CHANGES

➤ Santa Fe National Forest, Black Canyon CG, 7600’, heavily shaded, no campsite utilities, $5/night w/senior discount

➤ Arrived 10/8/17, low temp=23dF, 89% battery, 2 full LP tanks

➤ Lived VERY comfortably: Warm camper, movies each night, morning coffee. Gone daytime for trails, town, sightseeing, ABQ balloon festival, ABQ Aliner rally.

➤ Daily energy monitoring: **15 seconds** to 1) read battery % from display, 2) read two LP low liquid gauges

➤ Ran generator **once f/1hr.** Battery recharged f/51% to 100%.

➤ Left CG after 6.5 days on 10/15/17 @4:30am, battery @41%

➤ **8.3W/hour** average use. **46%** of an LP tank: 2.2gal, $8.78
ENERGY CONFIGURATION, 3/2018

Recharge Power

- Grid, 120vac
- Generator, 120vac
  - Auto Alternator+Inverter, 120vac
  - Solar Generator
    - Auto Alternator+7-pin
    - Auto Alternator+Cables

- Auto Alternator+Cables
- 2HrTmr
- Regulator
- Charger
  - 50A @14.4V
- Battery
  - LiFePo
  - 12vdc, 100ah

Storage+Charging

- Power Supply
  - 12vdc, 15A
- Relay
- Shunt Resistor
- Cell Equalize
- Recalibration
- Overcharge prevention
- Display
  - Battery Voltage
  - Current in/out
  - Cell-by-cell voltage
  - Cell-by-cell temperature

Loads (Red=High)

- LP Fridge, cooling
- LP Space Htr, 60% efficient
- LP Water Htr
- LP Stove - Cooking, Coffee
- LP Space Htr, 100% efficient

- Tubing
- LP (Propane), 20#

- Breakers
- 120vac, Space Heater
- 120vac, Air Conditioner
- 120vac, Coffee Pot
- 120vac, Computer charging

- Fuses
- 12vdc, Lighting
- 12vdc, Exhaust fan (Fantastic)
- 12vdc, White water pump
- 12vdc, Water Htr. Controls
- 12vdc, Lighter power plugs
- 12vdc, Toilet water pump
- 12vdc, LP/CO sensor/alarm
- 12vdc, LP Fridge controls
- 12vdc, LP Space Htr. fan controls

- Re-Fill Tanks
  - Swap tanks
1. BATTERY/CHARGER UPGRADE

**OEM**
- Converter
- Power Supply + Charger
- Battery, Lead Acid 12vdc, 100ah

**Modified**
- Power Supply 12vdc, 15A
- Charger 50A @14.4V
- Battery, LiFePo 12vdc, 100ah
- 2HrTmr
- Relay
- Shunt Resistor

**Alternatives not used**
- Battery, Lead Acid 6vdc, 100ah
- Battery, Lead Acid 6vdc, 100ah
- Lead Acid Golf Cart, Larger Batteries
- AGM Battery Lead Acid 12vdc

**OEM Lead Acid Batteries:**
- Very slow to charge
- 50% usable before deep discharge
- 300-500 deep discharges
- Heavy
- Requires venting (tongue, bumper)
- Weight distribution concerns

**LiFePo Batteries:**
- Very fast to charge (50%/hr)
- 80% usable before deep discharge
- 2000 deep discharges
- ~65% Weight of Lead Acid
- No venting required
- Location flexible w/o weight concerns

**ACCURATE %CHARGE (SOC)**
- Fast, easy

**Reduced recharge time = Less fuel, noise, time, oversight**
- Reduced oversight time = Easily done daily
1. BATTERY/CHARGER UPGRADE

Cell-by-cell voltage and temperature

Not Charging

Charging

47.4 Amps @13.71vdc
2. LP (LIQUID PROPANE) TANK MONITORING

OEM

Regulator

Modified

Regulator

Alternatives not used

Weight Measurement
Remove tank(s) from holder, measure weight, subtract tank weight, calculate % available.
Time consuming. Extra equipment to buy and carry.

LCD Level Measurement
Heat water, mount LCD strip on tank, pour hot water over LCD strip, read level, estimate % available.
Time consuming. Energy consuming. Accuracy challenge

Pressure Meter Measurement
Turn on LP appliance. Let pressures stabilize. Read meter.
Time consuming. Energy consuming. Accuracy challenge

Transducer Measurement
Buy & install battery Bluetooth sensor +transducer. Install phone app and/or battery display. Read levels from either phone or display.
Better accuracy. Batteries to maintain. High failure opportunities.
3. LP SPACE HEATER UPGRADE

**OEM**

- **Atwood 7916**
  - On=16kBtu/Hr (input)
  - **High 12vdc battery electric use**-3.4A when heating.
  - **Low LP heat efficiency** ~60% using heat exchanger.
  - **Loud and cyclic** due to required fan-blown air and outside venting of combustion air.

**Modified**

- **Wave 6, Camco 57341**
  - Hi=6kBtu/Hr, Med=?, Low=3.2kBtu/Hr.
  - Venting=1/4” to 1/2” vent and window open. Large 10”x13” pad at lower 760dF pad
  - **No altitude restriction**
  - **No electric use**
  - **99% LP efficiency**
  - **Silent operation.**

**Alternatives not used**

- **Mr. Heater Buddy, MH9BX**
  - High=9kBtu/Hr; Low=4kBtu/Hr.
  - “Unreliable over 7000 feet”.
  - **Very hot >960dF small pad (5”x4”) melts or burns clothing**
  - Venting=9 square inches minimum. CO and CO2 danger with improper venting or combustion.

- **Wave 3, Camco 57331**
  - High=3kBtu/Hr; Medium=??; Low=1.6kBtu/Hr.
  - **May be too small to quickly heat up larger ALiner campers.**

**Butane heaters**

  - 1. “does not burn well at high altitudes “ means incomplete combustion (CO and/or CO2 generation) and should not be used inside at high altitudes.
  - 2. “will not burn at all below freezing, as it is no longer liquid at that temperature.” Means it may not be relied on if allowed to be in freezing temps.

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**Electric use avoided = Extended battery time**
**Reduced propane use = Extended heating time**
4. ENERGY REDUCTIONS THRU PRACTICES

**OEM**

**Loads** *(Red=High)*
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- LP Space Htr, 60% efficient
- LP Water Htr
- LP Stove - Cooking, Coffee

**Tubing**
- 120vac, Space heater
- 120vac, Air conditioner
- 120vac, Coffee pot
- 120vac, Computer charging

**Breakers**
- 12vdc, Lighting
- 12vdc, Exhaust fan (Fantastic)
- 12vdc, White water pump
- 12vdc, Water Htr, Controls
- 12vdc, Lighter power plugs
- 12vdc, Toilet water pump
- 12vdc, LP/CO sensor/alarm
- 12vdc, LP Fridge controls
- 12vdc, LP Space Htr. fan+controls

**Fuses**
- Reduced electric

**Modified**

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**Fuses**
- Reduced electric

**During camping:**
- Replaced w/100% efficient LP Htr.
- Not used-HW obtained w/stove+kettle
- Reduced. Stove+kettle f/most cooking
- Added to replace OEM Space Htr.

- Small 300W 120vac pure sine wave inverter charges devices
- 1) In auto during travel (preferred) or 2) In camper from battery (avoided)

- Lower power LED replacements
- Not used-inefficient fan motor
- Not used-Container+spigot used
- Not used-Stove+kettle for hot water
- Sometimes used f/phone charging
- Required, low use
- Required. Kept on all the time.
- Required. Kept on all the time.
- Replaced w/100% efficient LP Htr.
5. RECHARGE POWER, SOLAR

How much power to expect?

**Sunny Day 5/24/17:**
- 6,000 W
- 4,600 W
- 76.7%
- 35,440 Wh/day
- 1,476 W/hr avg.

**Cloudy Day 5/28/17:**
- 6,000 W
- 1,600 W
- 26.7%
- 8,050 Wh/day
- 335 W/hr avg.

During trip, camper used 8.3 W/hr avg. for week.

But I don’t want to stay in Dallas Sun!!!

OTHER CONCERNS:
- Weather: Rain, snow, clouds
- Shading: Trees, mountains
- Latitude
- Theft
- Orientation
- Space in camper to store

Plan ‘B’ is needed for power!
5. RECHARGE POWER, SOLAR, BACKUP PLANS

➤ Grid, 120vac
  ➤ Go Home or go to another campground with grid power
➤ Generator, 120vac
  ➤ Carry and use a generator as a Solar backup
  ➤ Reliable, noisy, heavy, space challenge for small camper, Why carry solar?
➤ Auto Alternator+Inverter to camper charger
  ➤ Small, Lightweight
  ➤ Lead Acid batteries require long engine idling
  ➤ LiFePo batteries require 1hr engine idling for 50% charge every 3-5 days
  ➤ If auto mounted, can also power Fridge during driving
➤ Auto Alternator+Cables:
  ➤ Lead Acid batteries require long engine idling, tow vehicle battery disconnect
  ➤ LiFePo cannot be directly charged due to voltage mismatch

Testing in progress
All looks good. Some ‘lessons learned’.
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Display
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Fuses

Breakers
- Auto Alternator+Cables
- Solar Generator
- Grid, 120vac
- Generator, 120vac
- Auto Alternator+Inverter, 120vac
- Re-Fill Tanks
- Swap tanks

Battery
- LiFePo
- 12vdc,100ah

Control
- Voltage
- Current in/out
- Cell Equalize Recalibration
- Overcharge prevention

Regulator
- LP (Propane), 20#