Agenda

• Primary (single-use) Batteries
  • Alkaline
  • Lithium

• Secondary (rechargeable) Batteries
  • Ni-Cad, NiMH
  • Lithium Ion

• Real World Testing

• 12v Batteries
  • Lead Acid
  • Lithium Iron Phosphate (LiFePO4)
Alkaline

• **Pros**
  • Very low self-discharge (10 year shelf life)
  • Ubiquitous
  • Adapters available for most HTs

• **Cons**
  • Poor high current handling
  • Single use (non-rechargeable)
  • Possibility of leakage
  • Moderate energy density
Alkaline

- Alkaline batteries are 1.5v
- AAA
  - 500 - 1,100 mAh*
- AA
  - 1,500 - 3,000 mAh*
- C
  - 4,800 - 8,000 mAh*
- D
  - 9,000 - 17,000 mAh*
- 9v
  - 350 - 600 mAh*

*500 to 25 mA discharge current
Alkaline (Energizer)

Source: http://data.energizer.com/
Alkaline (Peukert’s Law)

- Peukert’s Law – In lead acid batteries, as the discharge current increases, the batteries available capacity decreases
- Presented by Wilhelm Peukert in 1897
- Has applications in alkaline batteries
Alkaline (Duracell Quantum)

AA Alkaline Battery Run-time at different current draw (to 0.8v)

- 1.5a: 22 mins, 550 mAh
- 1.0a: 35.6 mins, 593 mAh
- 0.5a: 176.7 mins, 1473 mAh
- 0.25a: 497.3 mins, 2072 mAh
Alkaline (Duracell Quantum)

AA Alkaline Battery Run-time at different current draw (to 1v)

- 1.5a: 6.8 mins, 170 mAh
- 1.0a: 10.2 mins, 170 mAh
- 0.5a: 91.4 mins, 762 mAh
- 0.25a: 427 mins, 1779 mAh
Nickel Metal Hydride (NiMH)

**Pros (Panasonic Eneloops and Tenergy Centuras)**
- Good for high current applications
- Rechargeable
- Relatively long shelf life (retains 80% capacity after 1 year)
- Will not leak
- Adapters available for most HTs

**Cons**
- Moderate energy density
- Only 1.2v vs 1.5v of alkalines
Nickel Metal Hydride (NiMH)

- Nickel Metal Hydride batteries are 1.2v
- AAA – Panasonic Eneloop Low Self-Discharge
  - 800 mAh*
- AA – Panasonic Eneloop Low Self-Discharge
  - 2,000 mAh*
- C – Tenergy Centura Low Self-Discharge
  - 4,000 mAh*
- D – Tenergy Centura Low Self-Discharge
  - 8,000 mAh*
- 9v – Tenergy Centura Low Self-Discharge
  - 200 mAh*

*500 mA discharge current
Nickel Metal Hydride (NiMH)

500 mA (0.5A) continuous discharge

Source: https://www.panasonic.com/global/consumer/battery/eneloop/technologies.html
Primary Lithium

- **Pros (Energizer Ultimate Lithium)**
  - Good for high current applications
  - Very long shelf life (20 year shelf life)
  - Will not leak
  - High energy density
  - Adapters available for most HTs

- **Cons**
  - Expensive
  - Single use (non-rechargeable)
Primary Lithium

- Primary Lithium batteries are 1.5v
- AA – Energizer Ultimate Lithium
  - 3,500 mAh

Source: http://data.energizer.com/
Rechargeable Lithium Batteries

- First proposed in 1973
- First rechargeable Lithium cell developed in 1980
- First commercial Lithium Ion battery developed in 1991
- Lithium Iron Phosphate battery proposed 1996
- Today Lithium batteries are found in smart phones, laptop computers, tablets, Bluetooth headsets, handi-talkies (HTs), cameras, flashlights, lanterns, power tools, electric bicycles, electric cars and so on
Lithium Ion

- **Advantages**
  - Rechargeable
  - Very lightweight
  - Able to provide a great deal of energy in a short amount of time
  - Very low self-discharge
  - Will not leak
  - No outgassing
  - High energy density
Lithium Ion

• So why are we so afraid of lithium ion batteries?
Lithium Ion

- So why are we so afraid of lithium ion batteries?
- Yes, there were those hoverboards that caught on fire
Lithium Ion

• So why are we so afraid of lithium ion batteries?
• Yes, there were those hoverboards that caught on fire
• And those darned mobile phones
Lithium Ion

- So why are we so afraid of lithium ion batteries?
- Yes, there were those hoverboards that caught on fire
- And those darned mobile phones
- And yes, there were even a few electric cars
Lithium Ion

- So why are we so afraid of lithium ion batteries?
- Yes, there were those hoverboards that caught on fire
- And those darned mobile phones
- And yes, there were even a few electric cars

- Hoverboards were using poor quality batteries to keep the costs down
- Samsung phone batteries also had quality control issues, but keep in mind, only 0.01% caught fire
- 5 times more likely to experience a fire in a gasoline powered vehicle
Lithium Ion

- **18650 batteries**
  - A little bigger than AA batteries
  - 3.7v
  - Recommend using ones with a protection circuit
  - Panasonic NCR18650B (3,400 mAh)
  - LG MJ1 18650F (3,500 mAh)
  - Used in many high output LED flashlights
  - Used in most USB Power Banks
  - Used in most laptop batteries
Li-Ion 18650 (Panasonic NCR18650B)

Li-Ion 18650 Battery Run-time at different current draw (to 2.8v)

- 1.5a: 126 mins 3152 mAh
- 1.0a: 180 mins 3180 mAh
- 0.5a: 360 mins 3194 mAh
- 0.25a: 783 mins 3265 mAh
Lithium Ion

• 18650 for your FT-60

Source: http://www.instructables.com/id/DYI-Lithium-battery-for-handheld-radio-Yaesu-FT-60/
Test Methodology

• West Mountain Radio Computerized Battery Analyzer (CBA) IV
• WMR CBA Software V2.4.16.0 with Extended License
• Custom (i.e. homemade) interfaces to the various battery packs
Test Methodology

- Used the Multi-Discharge test using the following settings
  - Low-Voltage cut-off: 5.5v
  - 1s steps until cut-off voltage is met
  - Three step discharge
    - 5s @ 1.6a (transmit)
    - 22s @ 0.2a (receive)
    - 33s @ 0.02a (idle)
- All primary/single-use batteries were “fresh”
- All secondary/rechargeable batteries were fully charged before testing
FT-60: Std Nickel Metal Hydride (NiMH) 7.2v 1400 mAh battery (FNB-83)

- 8.4v to start
- Drops to 7.9v on PTT
- 5:45:08 at 6v cut-off
- 6:10:05
- 1284 mAh
Test Results

FT-60: Std Nickel Metal Hydride (NiMH) 7.2v 1400 mAh battery (FNB-83)
1 Month After Full Charge

- 7.87v to start
- Drops to 7.3v on PTT
- 5:16:08 at 6v cut-off
- 5:33:05 1163 mAh
- Loss of ~ 30 mins
- Loss of ~ 37 mins
FT-60: Lithium Ion 7.4v 2000 mAh battery (YV38L3-D / FNB-V67Li)

- 8.3v to start
- Drops to 7.7v on PTT
- 5.5v cut-off
- 9:06:08 at 6v cut-off
- 9:14:03 1914 mAh

http://www.cutratebatteries.com/products/standard-ft-60r-battery
Test Results

FT-60: Lithium Ion 7.4v 2000 mAh battery
1 Month After Full Charge

- 8.2v to start
- Drops to 7.5v on PTT
- Loss of ~ 71 mins
- Loss of ~ 76 mins
- 7:55:03 at 6v cut-off
- 7:57:05 1669 mAh
- 5.5v cut-off

http://www.cutratebatteries.com/products/standard-ft-60r-battery
Test Results

Installation of FBA-25 Alkaline Battery Case

“Note that the power output and battery life will be much shorter when using Alkaline AA cells. They should be considered an emergency backup power source only, for this reason”
Test Results

FT-60: AA battery pack 6x Duracell Quantum Coppertop batteries

- 9.6v to start
- Drops to 7.8v on PTT
- 5.5v cut-off
- 1:18:00 at 6v cut-off
- 2:05:06 434 mAh

Rachel Kinoshita – KK6DAC
Test Results

FT-60: AA battery pack 6x
Energizer Ultimate Lithium batteries

9.7v to start

Drops to 7.3v on PTT

5.5v cut-off

13:19 at 6v cut-off

13:40:06
2840 mAh

Rachel Kinoshita – KK6DAC
Test Results

61 alkaline batteries / $43.00 / 57.36 oz (3.5 lbs)

Alkaline: 1:18 to 6v
Lithium: 13:19 to 6v

Lithiums last 10.24x longer than Alkalines

10.24 x 6 batteries = 61
Installation of FBA-25 Alkaline Battery Case

“The **FBA-25A** must not be used with rechargeable cells. The **FBA-25A** does not contain the thermal and over-current protection circuits (provided in the "FNB" series of Ni-MH Battery Packs) required when utilizing Ni-Cd or Ni-MH cells.”
Test Results

FT-60: AA battery pack 6x Panasonic Eneloop 2000 mAh batteries

- 8.5v to start
- Drops to 7.9v on PTT
- 5.5v cut-off
- 8:36 at 6v cut-off
- 8:46:05 1752 mAh
Test Results

40 alkaline batteries / $27.77 / 37 oz (2.3 lbs)

$12.00 / 2.7 oz

Rachel Kinoshita – KK6DAC

Alkaline: 1:18 to 6v
NiMH: 8:36 to 6v

NiMHs last 6.62x longer than Alkalines

6.62 x 6 batteries = 39.7
Test Results

40 alkaline batteries / $27.77 / 37 oz (2.3 lbs)

But wait, the Eneloop’s are rechargeable up to 2100 times

$12.00 / 2.7 oz
Test Results

$58,320 / 2.43 tons

83,354

➢ It takes 20Wh or 0.02 kWh to charge one Eneloop
➢ All six would take 0.12 kWh
➢ We pay an average of $0.20 per kWh
➢ Charging all six batteries costs less than 2 ½ ¢
➢ To recharge them 2100 times would cost $50.40

$12.00 / 2.7 oz

(plus $50.40 to recharge then 2100 times)
Test Results

$12,206 / 254 lbs

8,137

$12.00 / 2.7 oz
(plus $50.40 to recharge them 2100 times)

➢ It takes 20Wh or 0.02 kWh to charge one Eneloop
➢ All six would take 0.12 kWh
➢ We pay an average of $0.20 per kWh
➢ Charging all six batteries costs less than 2 ½ ¢
➢ To recharge them 2100 times would cost $50.40

Rachel Kinoshita – KK6DAC
Test Results

Baofeng: Std battery pack
1800 mAh Lithium Ion battery

8.25v to start

Drops to 7.5v on PTT

5.5v cut-off

6:33:05
1314 mAh
Test Results

Baofeng: Ext battery pack
3400 mAh Lithium Ion battery

8.28v to start
Drops to 7.97v on PTT
5.5v cut-off
12:33:06 2518 mAh
Test Results

Baofeng BL-5 AA Battery Pack
Uses 5x AA alkaline batteries (7.5v) plus an included dummy cell or 6x AA NiMH batteries (7.2v)

Unlike the FT-60 which can handle voltages from 9v to 6v, a Baofeng won’t transmit if the battery voltage is higher than about 8v.
Test Results

Baofeng: AA battery pack 5x Duracell Quantum Coppertop batteries

- 8v to start
- Drops to 6.4v on PTT
- 5.5v cut-off
- 0:50:05 152 mAh
Test Results

Baofeng: AA battery pack 5x Energizer Ultimate Lithium batteries

- **8.1v to start**
- **Drops to 6v on PTT**
- **5.5v cut-off**
- **12:59:06 2345 mAh**
Test Results

78 alkaline batteries / $54.60 / 73.32 oz (4.6lbs)

$7.50 / 2.5 oz

Alkaline: 0:50 to 6v
Lithium: 12:59 to 6v

15.58 x 5 batteries = 78

Lithiums last 15.58x longer than Alkalines
Test Results

Baofeng: AA battery pack 6x Panasonic Eneloop 2000 mAh batteries

- 8.5v to start
- Drops to 7.9v on PTT
- 5.5v cut-off
- 8:46:05
- 2752 mAh

Rachel Kinoshita – KK6DAC
Test Results

53 alkaline batteries / $37.10 / 49.82 oz (3.11 lbs)

$12.00 / 2.7 oz

Alkaline: 0:50 to 6v
NiMH: 8:46 to 6v

NiMHs last 10.52x longer than Alkalines

10.52 x 5 batteries = 52.6
Test Results

$77,322 / 3.25 tons

$12.00 / 2.7 oz (plus $50.40 to recharge then 2100 times)

110,460

- It takes 20Wh or 0.02 kWh to charge one Eneloop
- All six would take 0.12 kWh
- We pay an average of $0.20 per kWh
- Charging all six batteries costs less than 2 ½ ¢
- To recharge them 2100 times would cost $50.40
Conclusion

- **Use the highest capacity Li-Ion battery available for your radio**
- **When using the AA adapter**
  - Alkaline batteries are the worst choice. Use as the last resort
  - Energizer Ultimate Lithium batteries are the best choice for single-use batteries
    - Extremely low self-discharge (95% of capacity after 20 years)
    - Handles high current discharge
    - About $1.50 per battery
  - Panasonic Eneloop batteries are the best choice for rechargeable batteries
    - Relatively low self-discharge (85% of charge after 1 year)
    - Can be recharged up to 2100 times
    - Handles high current discharge
    - About $2.00 per battery
    - *Never charge from the radio*
Small Battery Chargers

- **Maha PowerEx MH-C808M**
  - Can charge any combination of 8 AAA, AA, C, D (MaHa MH-C801D or MH-C800S if you only want to charge AA and AAA)
  - Fast and slow charge mode
  - Requires 120vac

- **NiteCore D4**
  - Can charge any combination of 4 AA, AAA, AAAA, C, 26650, 22650, **18650**, 17670, 18490, 17500, 18350, 16340, 14500, 10440
  - Can charge from either 120vac or 12vdc (adapter included)

- **Xtar Dragon VP4**
  - Can charge any combination of 4 AAAA, AAA, AA, A, SC, C, D, 10440, 14500, 14650, 16340, 17335, 17500, 17670, 18350, 18490, 18500, **18650**, 22650, 2550, 26650, 32650
  - 0.5a to 2.0a charging modes
  - Can charge from either 120vac or 12vdc (adapter included)
12v Batteries

- **Why 12v batteries**
  - Mobile radios
  - Recharge HT radios, mobile phones, tablets, laptops, rechargeable batteries, lighting, television, etc
  - Easy to charge from solar or from your car
- **Lots of different size batteries available from small 7Ah sealed lead acid (SLA) to large 100+Ah absorbed glass mat (AGM)**
- **Different chemistries available include lead acid, lithium iron phosphate (LiFePO4), Lithium-Ion...you can even make a 12v battery from alkaline or NiMH batteries**
- **Amp Hour Measurement is typically at 20 hours**
  - Peukert Effect
  - As the discharge amps increase, the batteries available capacity decreases
Batteries

➢ Capacity (Amp Hour Rating)
  • How many amps can be delivered over a period of time before the battery is completely dead

<table>
<thead>
<tr>
<th>CAPACITY B Amp-Hours (AH)</th>
<th>ENERGY (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trojan Group 27 - 100 AH AGM Battery</td>
<td></td>
</tr>
<tr>
<td>5-Hr Rate 15.4 amps</td>
<td>10-Hr Rate 8.2 amps</td>
</tr>
<tr>
<td>77</td>
<td>82</td>
</tr>
</tbody>
</table>
Lead Acid

- Flooded (Automobile starter, Maintenance free, Deep cycle, Golf cart batteries)
  - Peukert constant = 1.6

- Sealed Lead Acid
- Gel
  - Peukert constant = 1.25

- Absorbed Glass Matte (AGM)
  - Peukert constant = 1.15
Lead Acid

• **Pros**
  - **Flooded** (Automobile starter, Maintenance free, Deep cycle, Golf cart batteries)
    • Proven technology
    • Relatively inexpensive
  - **Sealed/Gel**
    • No outgassing
    • Can be installed in any position
  - **Absorbed Glass Matte (AGM)**
    • No outgassing
    • Can be installed in any position
    • Relatively long life (5+ years)

• **Cons**
  - **Flooded**
    • Heavy
    • Outgas
    • Spill hazard
  - **Sealed/Gel**
    • Heavy
  - **AGM**
    • Heavy
    • Expensive
Lead Acid

12v Lead Acid Voltage Curve

Most mobile rigs operate to 11.7v

At 50% or more DoD damage occurs

Rachel Kinoshita – KK6DAC
Lithium Iron Phosphate (LiFePo4)

- **Pros**
  - Very low self-discharge
  - Relatively flat discharge curve
  - Can be recharged thousands of times
  - At 3.2vdc per cell, 4 cells in series (4s) has a nominal voltage of 12.8v and max voltage of 14.2v
  - Will not leak
  - No outgassing
  - High energy density
  - Can be charged with a power supply or charger set to 14.2v to 15.1v*
  - Unlike Li-Ion, LiFePO4 is very safe
  - Peukert constant = 1.01 or less

- **Cons**
  - Expensive

*With a Bioenno BMS. May also work with other LiFePO4 battery BMS
Lithium Iron Phosphate (LiFePo4)

Most mobile rigs operate to 11.7v

Never discharge below 11v (2.75v per cell)
Lithium Ion (Li Ion)

**Pros**
- Low self-discharge
- Relatively flat discharge curve
- Will not leak
- No outgassing
- High energy density
- Relatively Inexpensive

**Cons**
- Hard to configure for 12v systems (3.7v per cell nominal / 4.2v peak – 3s gives us 11.1 to 12.6 while 4s gives us14.8 – 16.8)
- Must balance the cells using a proper charger
- Can be dangerous if over-charged or discharged or shorted
Test methodology

- **Used the Multi-Discharge test using the following settings**
  - Low-Voltage cut-off: 11.2v
  - 1s steps until cut-off voltage is met
  - Three step discharge (simulate 50w transmit)
    - 15s @ 10.3a (transmit)
    - 30s @ 1a (receive)
    - 15s @ 0.1a (idle)
  - Three step discharge (simulate 25w transmit)
    - 15s @ 6.5a (transmit)
    - 30s @ 1a (receive)
    - 15s @ 0.1a (idle)
- **Batteries were fully charged before testing**
- Sealed Lead Acid battery used was an ExpertPower EXP 12200 12v, 20 Ah purchased on Amazon for $38.00; 12.5 lbs
- LiFePO4 battery used was a Bioenno BLF-1220W/A 12v, 20 Ah purchased at Ham Radio Outlet $192.95; 5.5 lbs
Sealed Lead Acid 12v 20 AH battery (50w simulation)

- 13.2v to start
- Drops to 12.3v on PTT
- 11.2v cut-off
- 4:49:11 15 Ah
Test Results

Sealed Lead Acid 12v 20 AH battery
(50w simulation)

13.2v to start

Drops to 12.3v on PTT

11.2v cut-off

3:32:11 @ 11.7v

4:49:11 15 Ah

Rachel Kinoshita – KK6DAC
Test Results

Sealed Lead Acid 12v 20 AH battery (25w simulation)

- 13.3v to start
- Drops to 12.75v on PTT
- 11.2v cut-off
- 7:45:11 16.7 Ah

Rachel Kinoshita – KK6DAC
Sealed Lead Acid 12v 20 AH battery
(25w simulation)

- 13.3v to start
- Drops to 12.75v on PTT
- 11.2v cut-off
- 6:17:12 @ 11.7v
- 7:45:11 16.7 Ah
LiFePO4 12v 20 AH battery (50w simulation)

- 14.5v to start
- Drops to 13.5v on PTT
- 11.2v cut-off
- 6:14:14 19.5 Ah
LiFePO4 12v 20 AH battery (50w simulation)

- 14.5v to start
- Drops to 13.5v on PTT
- 11.2v cut-off
- 6:08 @ 11.7v
- 6:14:14 19.5 Ah
Test Results

LiFePO4 12v 20 AH battery (25w simulation)

- 14.4v to start
- Drops to 13.4v on PTT
- 11.2v cut-off
- 9:00:11 19.5 Ah
Test Results

LiFePO4 12v 20 AH battery
(25w simulation)

- 14.4v to start
- Drops to 13.4v on PTT
- 11.2v cut-off
- 8:55 @ 11.7v
- 9:00:11 19.5 Ah

Rachel Kinoshita – KK6DAC
Test Results

$53.00 / 17.5 lbs

$192.95 / 5.5 lbs
Test Results

$213.00 / 70.1 lbs

Can be fully recharged up to 500 times

$192.95 / 5.5 lbs

Can be fully recharged up to 2000 times
Using Batteries in Emergency Communications

• Post Katrina, FEMA was left with more trailers than they knew what to do with
Using Batteries in Emergency Communications

- The problem was exacerbated because many of the trailers had toxic levels of formaldehyde

[Image of trailer window with a sign saying 'NOT TO BE USED FOR HOUSING']
Using Batteries in Emergency Communications

• In late 2014 / early 2015 the Menlo Fire District acquired a surplus FEMA Katrina trailer
Using Batteries in Emergency Communications

- Menlo Fire purchased the CERT trailer to provide a platform for communications during an emergency or disaster.
- The trailer was outfitted with amateur radios, computers, monitors, a generator, antennas and other accessories necessary to operate.
- In that configuration it required manual charging of the battery on a regular basis to prevent battery damage due to low voltage.
- Generators require fuel, regular oil changes and have moving parts which can fail.
- In a disaster, gasoline for the generator may become a scare resource.
- Configuring the trailer to run stand-alone with only batteries and PV panels would ensure independent operations during a disaster.
Menlo Park CERT Communications Trailer
Menlo Park CERT Communications Trailer
Menlo Park CERT Communications Trailer
Menlo Park CERT Communications Trailer
Menlo Park - Proposed System

- Batteries will automatically be maintained
- Trailer will always be ready to be deployed
- Provides sufficient power to run radios, computers and lights for an extended period of time
- Reduces or removes dependency on gasoline or propane generator
- Designed for growth
Menlo Park - Proposed System

- 60A MPPT Solar Charge Controller
- 6 slot Solar Combiner box
- 4x 250w PV Panels
- 4x 140Ah AGM Batteries
Menlo Park – Completed System

4x 250w polycrystalline 24v PV panels

Midnite Solar Combiner Box
4x 10-150vdc
10a breakers

Outback MX60
MPPT Charge Controller

100a Circuit Breaker

4x Trojan 12v 140 Ah AGM Batteries
Menlo Park CERT Communications Trailer

Automatic Packet Reporting System (APRS) Telemetry
Menlo Park CERT Communications Trailer
Menlo Park CERT Communications Trailer

**Telemetry from KK6DAC-15**

**Comment:** Battery: 13.4V Temp: 77F

**Microphone messages:** Off duty

**Location:**
- 37°28.69' N 122°28.98' W - locator CMJ7WZ40 - show map - static map
- 0.8 miles Northwest bearing 324° from East Palo Alto, San Mateo County, California, United States
- 2.4 miles Northeast bearing 47° from Menlo Park, San Mateo County, California, United States
- 16.9 miles Northwest bearing 305° from San Jose, Santa Clara County, California, United States
- 25.2 miles Southeast bearing 144° from San Francisco, San Francisco County, California, United States

**Last position:**
- 2017-10-06 16:25:25 PDT (1m55s ago)
- 2017-10-06 16:25:25 PDT local time at East Palo Alto, United States

**Last telemetry:**
- 2017-10-06 15:59:42 PDT (27m ago)
- 2017-10-06 15:59:42 PDT local time at East Palo Alto, United States

**Altitude:** 33 ft

**Values:**
- Channel 1: 134 (TLM: 134 EQN: 0,1,0)
- Channel 2: 76 (TLM: 76 EQN: 0,1,0)
- Channel 3: 255 (TLM: 255 EQN: 0,1,0)
- Channel 4: 91 (TLM: 91 EQN: 0,1,0)
- Channel 5: 67 (TLM: 67 EQN: 0,1,0)

**Bit sense:** 1 2 3 4 5 6 7 8 (TLM: EITS: 11111111)

Telemetry history graphs for KK6DAC-15

[24 hours - 48 hours - week - month - year]

KK6DAC-15 Channel 1 2017-10-04 16:28:02 -> 2017-10-06 15:59:42 PDT

Graph showing telemetry data over time.
Menlo Park – 48 Hours of Collected Data

KK6DAC-15 Channel 1 2017-10-01 16:12:57 -> 2017-10-03 16:02:29 PDT

Absorption
Bulk
Float
Idle
Idle

KK6DAC-15 Channel 2 2017-10-01 16:12:57 -> 2017-10-03 16:02:29 PDT

80
75
70
65
60
55
50

Oct 2 0:00 Oct 2 8:00 Oct 2 16:00 Oct 3 0:00 Oct 3 8:00 Oct 3 16:00

Oct 2 0:00 Oct 2 8:00 Oct 2 16:00 Oct 3 0:00 Oct 3 8:00 Oct 3 16:00
Menlo Park – 1 Month of Collected Data

KK6DAC-15 Channel 1 2017-09-03 16:00:00 -> 2017-10-03 16:00:00 PDT

KK6DAC-15 Channel 2 2017-09-03 16:00:00 -> 2017-10-03 16:00:00 PDT
Menlo Park – How Are We Doing this Winter?

Even on rainy, overcast days we manage to get to 13.3v
## Menlo Park CERT – What Did it Cost?

<table>
<thead>
<tr>
<th>Qty</th>
<th>Desc</th>
<th>Price</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Trojan 12v 140ah AGM Battery</td>
<td>$420.00</td>
<td>$1,680.00</td>
</tr>
<tr>
<td>4</td>
<td>Amerisolar 250w 24v PV panel</td>
<td>$170.00</td>
<td>$680.00</td>
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<tr>
<td>2</td>
<td>Solarline 50' cables with MC4 connectors</td>
<td>$44.00</td>
<td>$88.00</td>
</tr>
<tr>
<td>4</td>
<td>Aluminum Z bracket kit</td>
<td>$9.00</td>
<td>$36.00</td>
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<td>1</td>
<td>Outback FX60 12-48v MPPT Charge Controller</td>
<td>$602.00</td>
<td>$602.00</td>
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<tr>
<td>1</td>
<td>Midnite Solar MNPV6 Combiner Box</td>
<td>$95.00</td>
<td>$95.00</td>
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Conclusion

- Portable Operations
  - Lead acid batteries are relatively inexpensive, but the trade-off is weight, capacity, self-discharge and overall life; Only sealed lead acid batteries should be used to prevent spillage.
  - LiFePO4 batteries are less than half the weight of an equivalent SLA battery, has more useable capacity, can sit for long periods of time without losing much charge and has 4 times the life. The trade-off is price, but in the long-term they pay for themselves.

- Home / Base Operations
  - Weight is less of an issue so lead acid batteries have fewer disadvantages. Never use flooded batteries inside the house due to out-gassing. Need to keep them on a float charge when not in use.
  - LiFePO4 batteries will have a much longer life and will be easier to move around, but are expensive, especially for occasional use.
Questions

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