FRIENDS OF THE EEL RIVER:
INITIAL FEASIBILITY EVALUATION (Feb-2017) FOR REPLACING POTTER-VALLEY HYDROPOWER WITH SOLAR ENERGY

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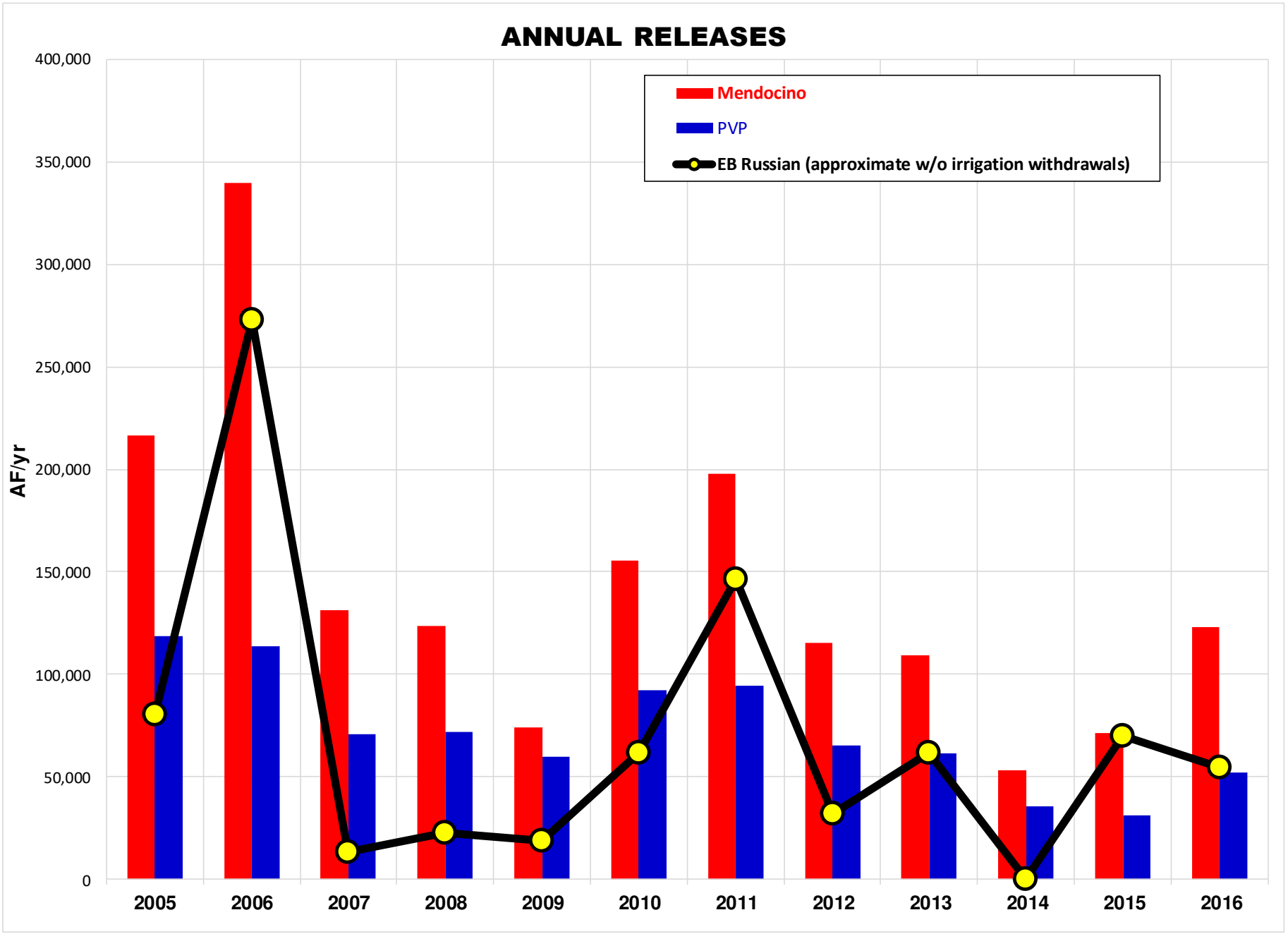
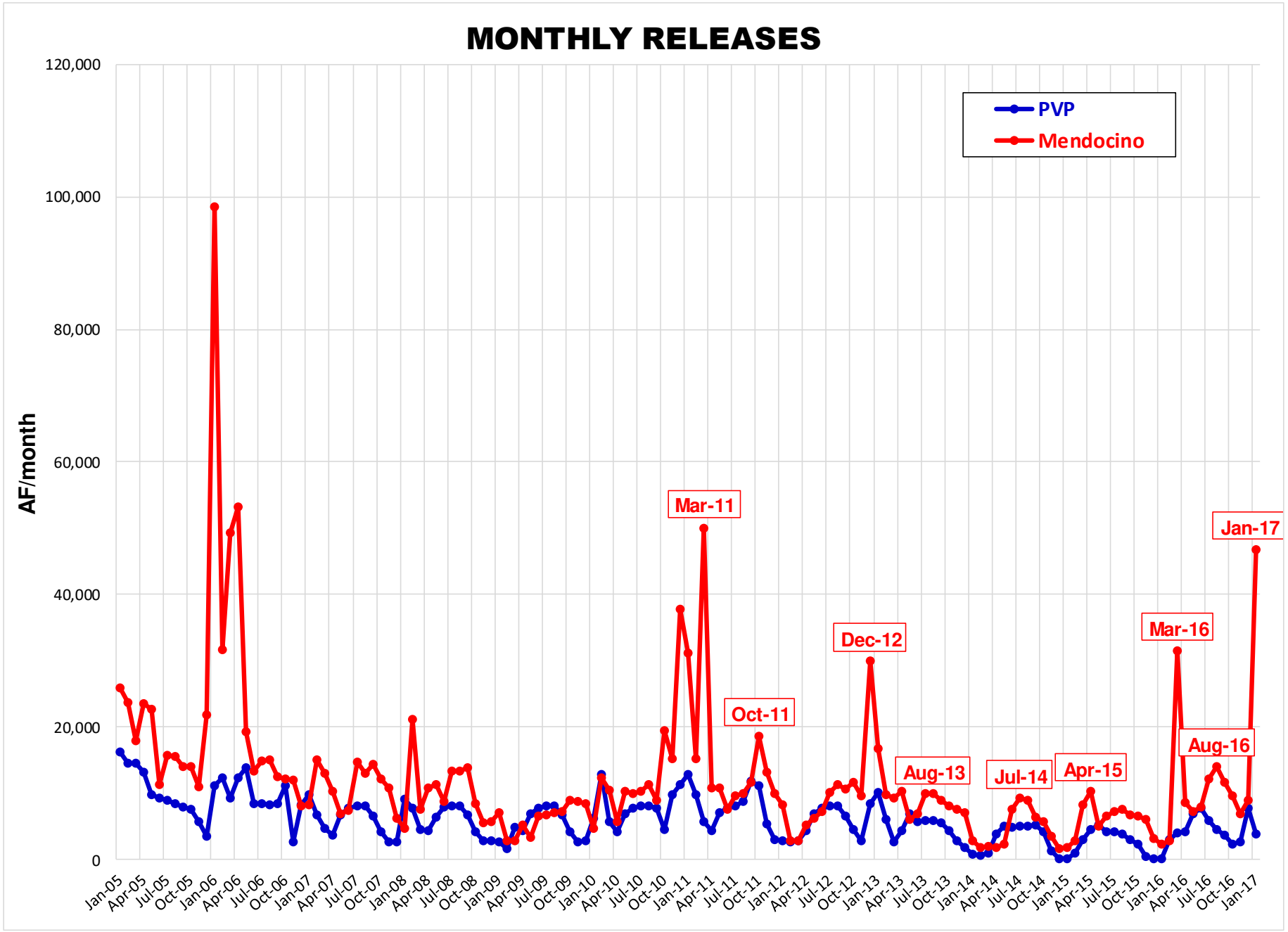
CONCLUSIONS

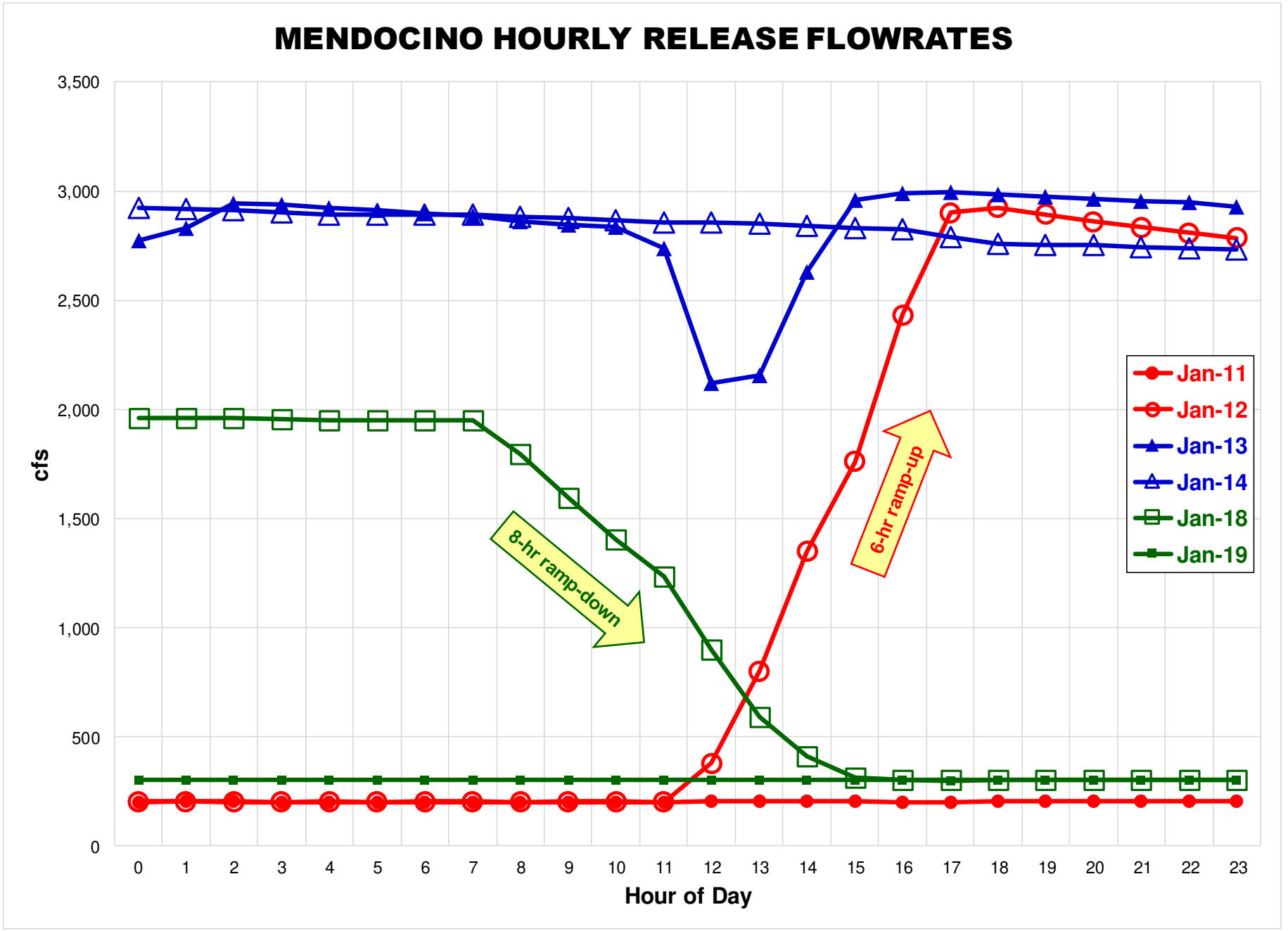
1. **Feasible to replace hydropower with solar+batteries within Ukiah's city limits:**
   - I. 3 acres of solar photovoltaics (13 MW rated) on parking lots
   - II. 27 MWh battery storage (max; not optimized)
   - III. $40 million installed cost
2. **Cost of solar could be justified by comparing with PVP upgrades**
3. **Replacement costs can be reduced by combining solar systems with:**
   - i. End-use load reduction (efficiency)
   - ii. Non-battery end-use storage (load shifting)
   - iii. Wind power



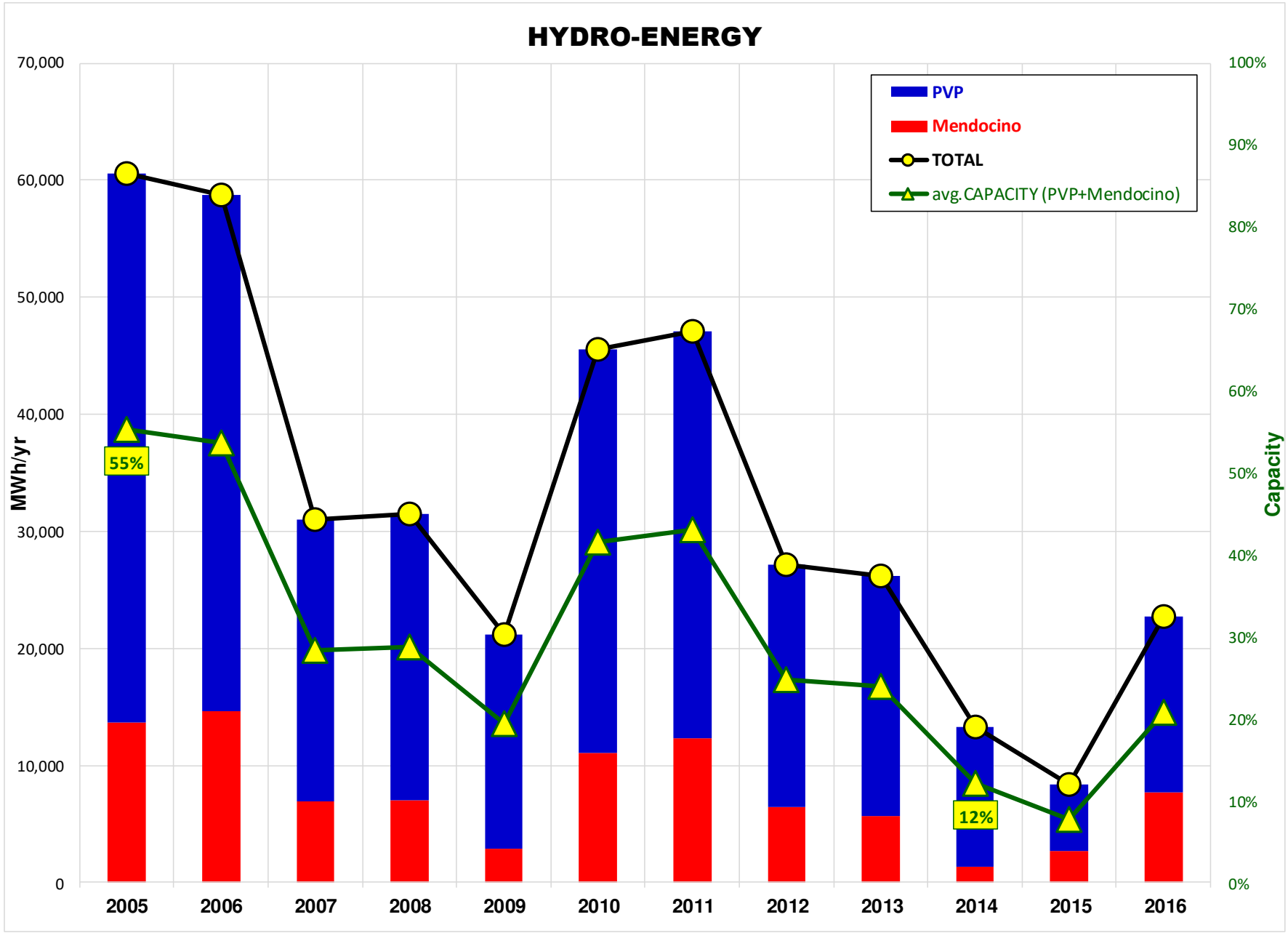
Releases from Lake Mendocino are larger than the approximate inflows from the East branch of the Russian River (minus the withdrawals by irrigation districts). The additional water is from PVP releases from the Eel River.



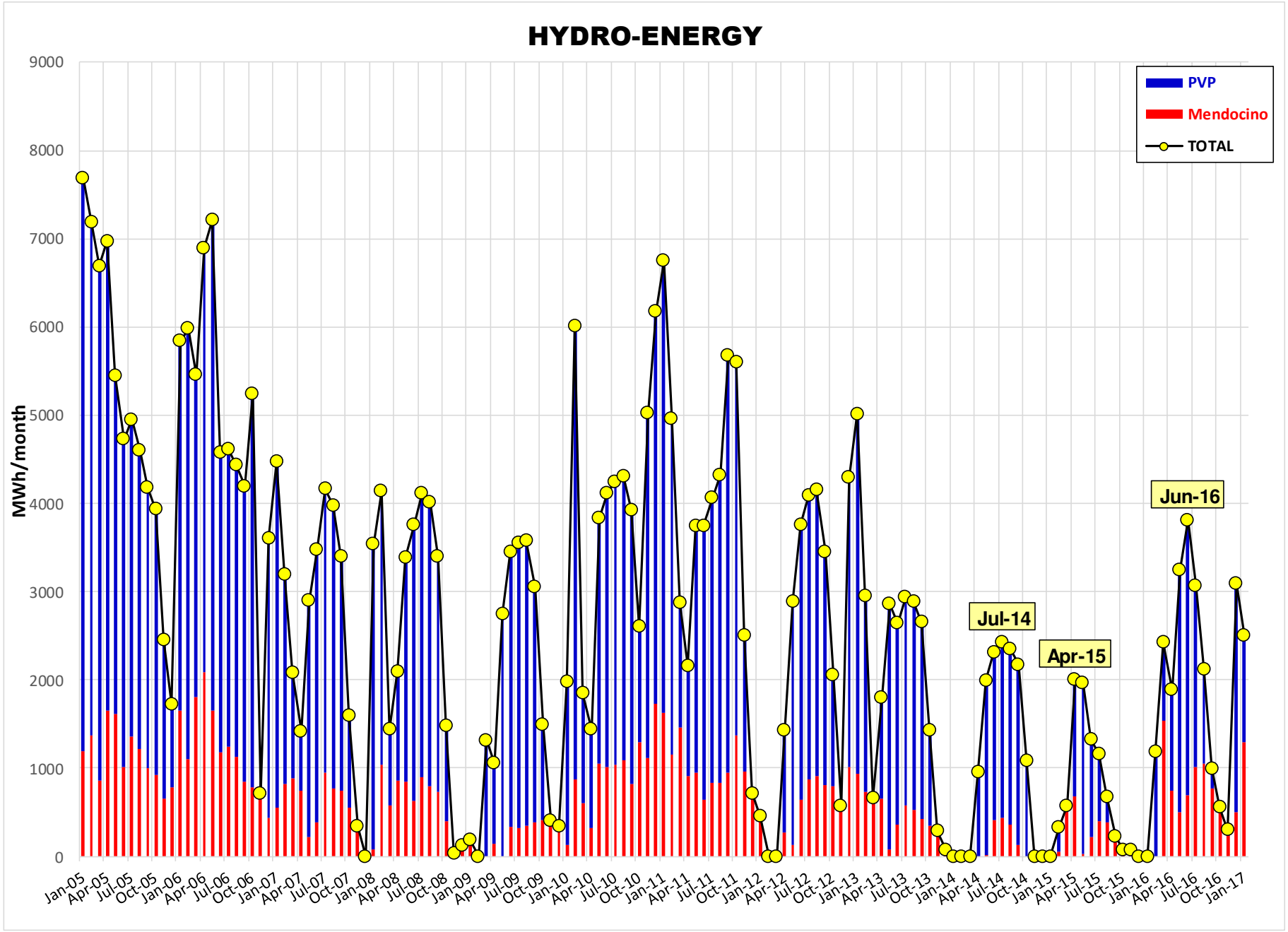
Largest releases from Lake Mendocino are in winter for flood control, but there are also smaller summer peaks for Russian River water supply



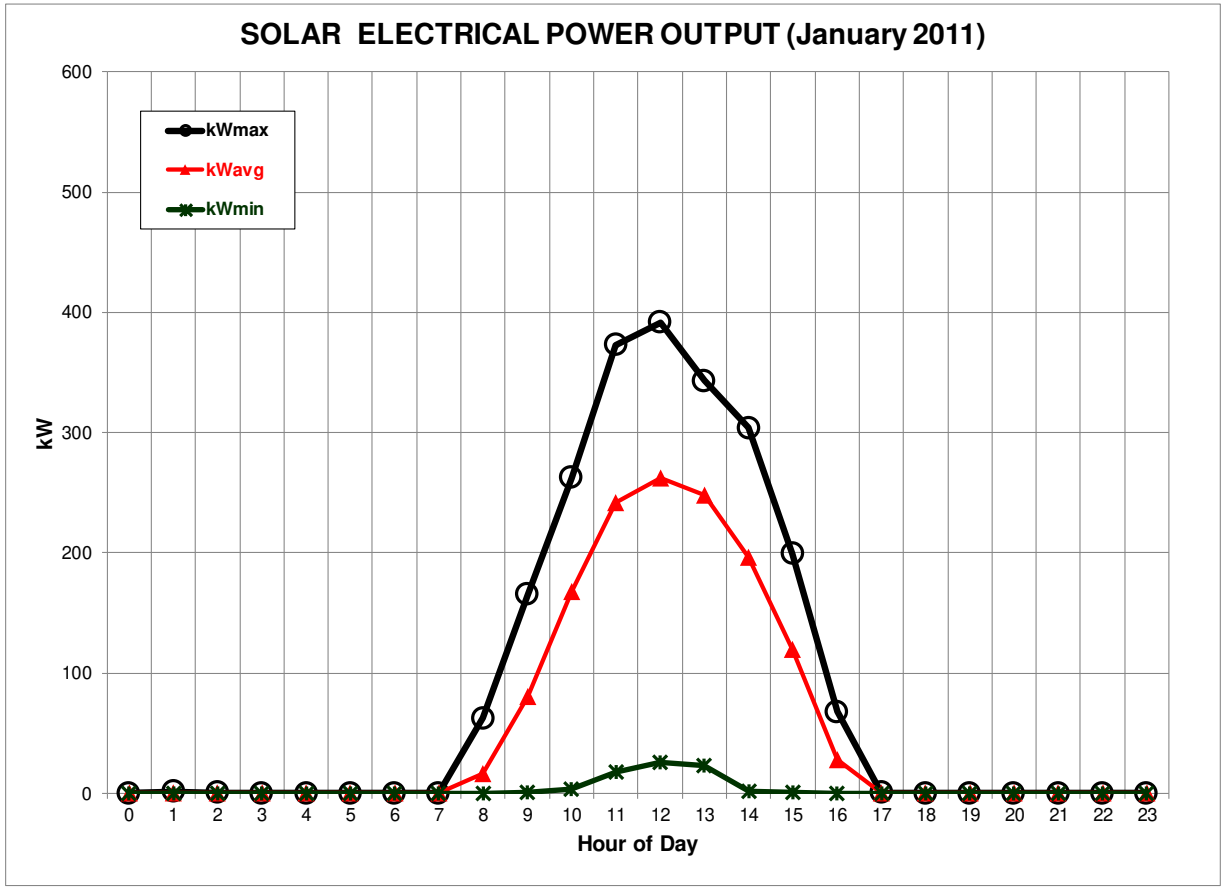
- **Releases from Lake Mendocino are almost always constant over a 24-hour period, but when storms occur, the flows are ramped up/down over 6-8 hours**
- **The ramps up/down also change the power output of the turbines**

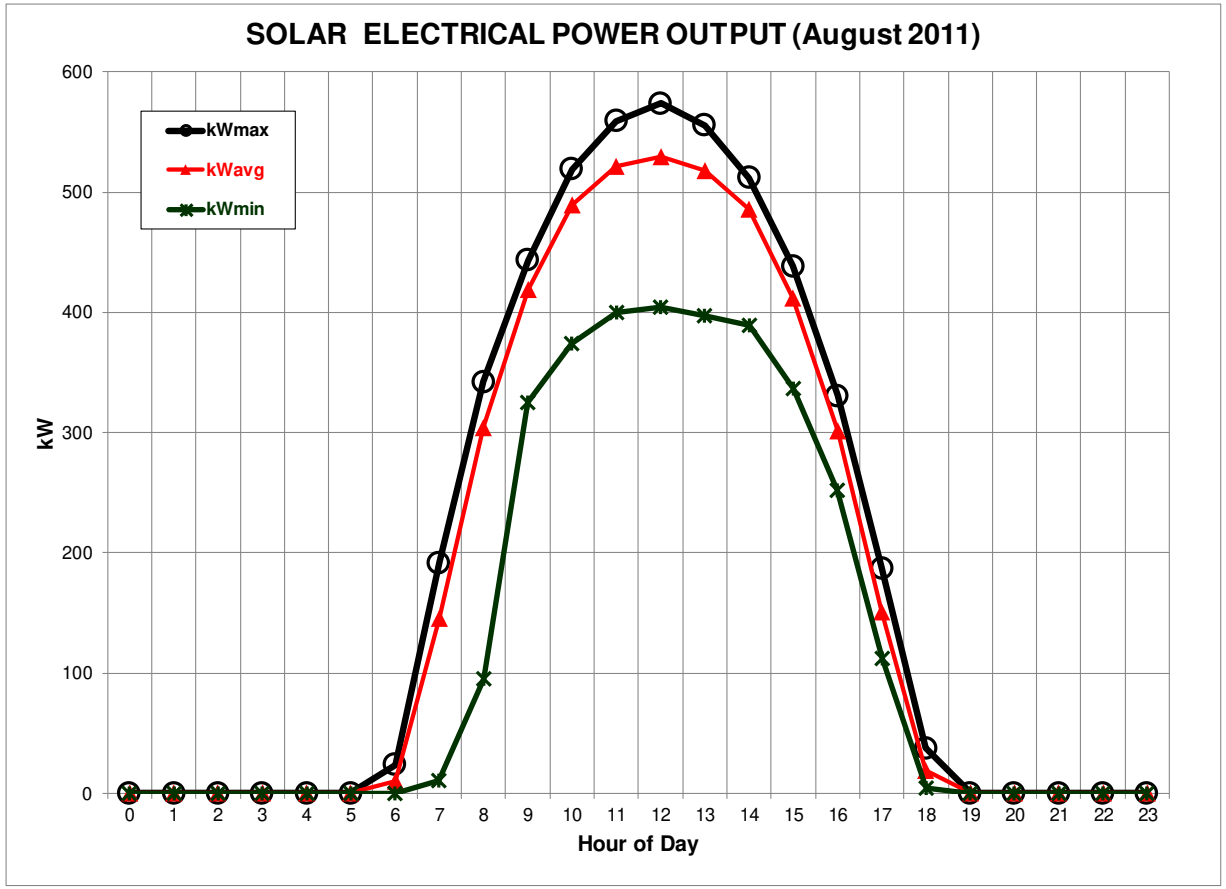


- **Hydropower is extremely variable, and in recent years has been trending down.**
- **The hydropower plants (PVP and Lake Mendocino) have been operating at less than 50% of full capacity for many years.**
- **Daily flow from Mendocino is almost always constant over a 24-hr period (previous graph). Power output was estimated from total turbine rating (3.5 MW), between min/max limits for daily flow (104-400 cfs) and head (28-73 ft). The operation of each turbine (2.5 MW and 1 MW) was not known.**
- **Only daily flow data was available for PVP, and it was assumed that it is constant over a 24-hour period. Power output was estimated from total turbine rating (9 MW), between min/max limits for flow. (70-270 cfs) The actual operation of the turbines was not known.**

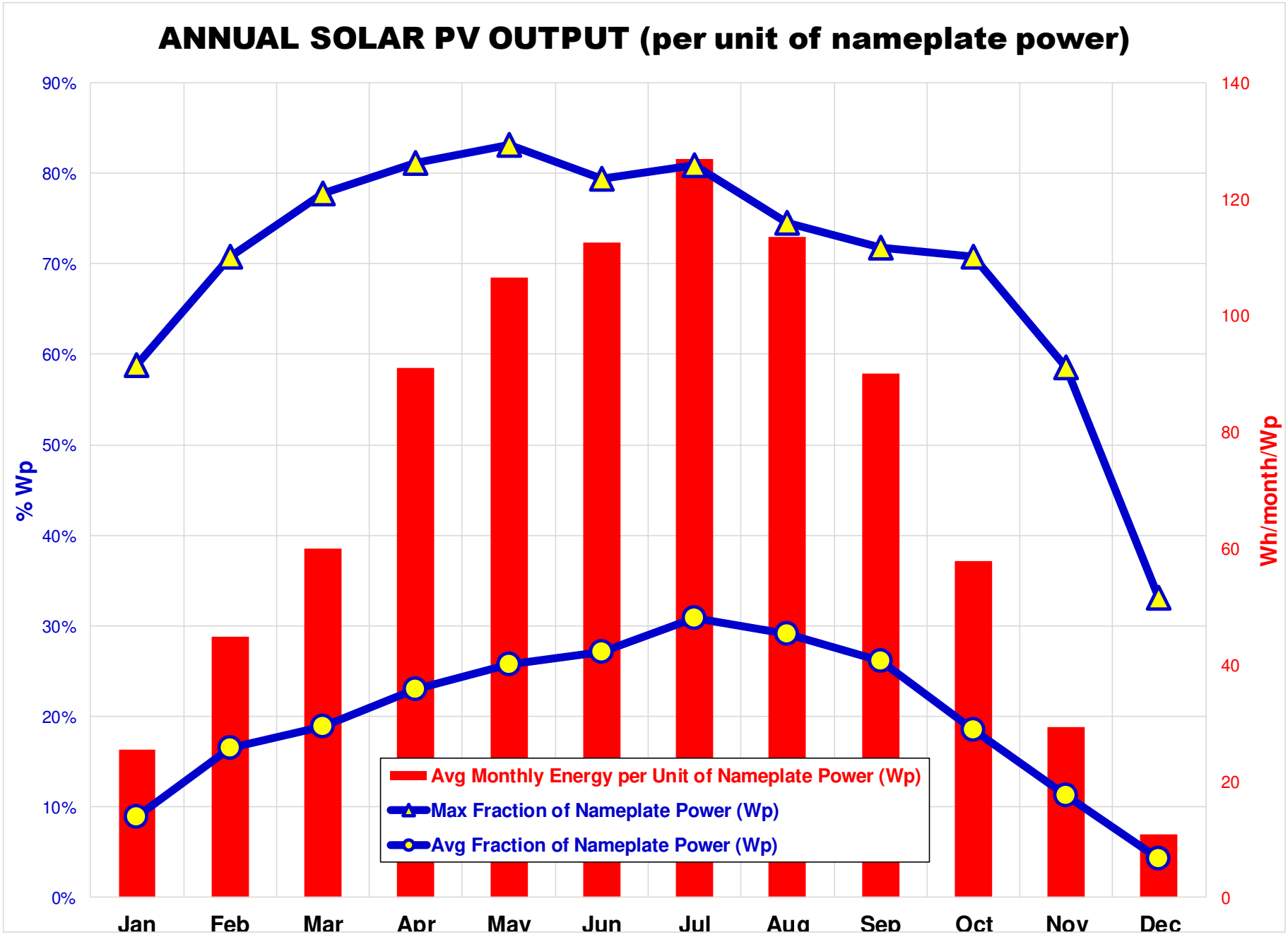


- **Hydropower is extremely variable, and in recent years is often zero in winter (when solar would also be low). This implies that local demands require grid supply – and are not dependent on hydro.**
- **PVP releases are highest in summer when Eel River needs are highest. This is exactly when solar PV would also be highest and could easily displace hydro.**
- **Ukiah's hydropower from Lake Mendocino has actually only been in operation since 2007, and is even more variable than PVP – with longer periods of zero production because the reservoir is too low. Summer hydro could be easily displaced by solar PV.**

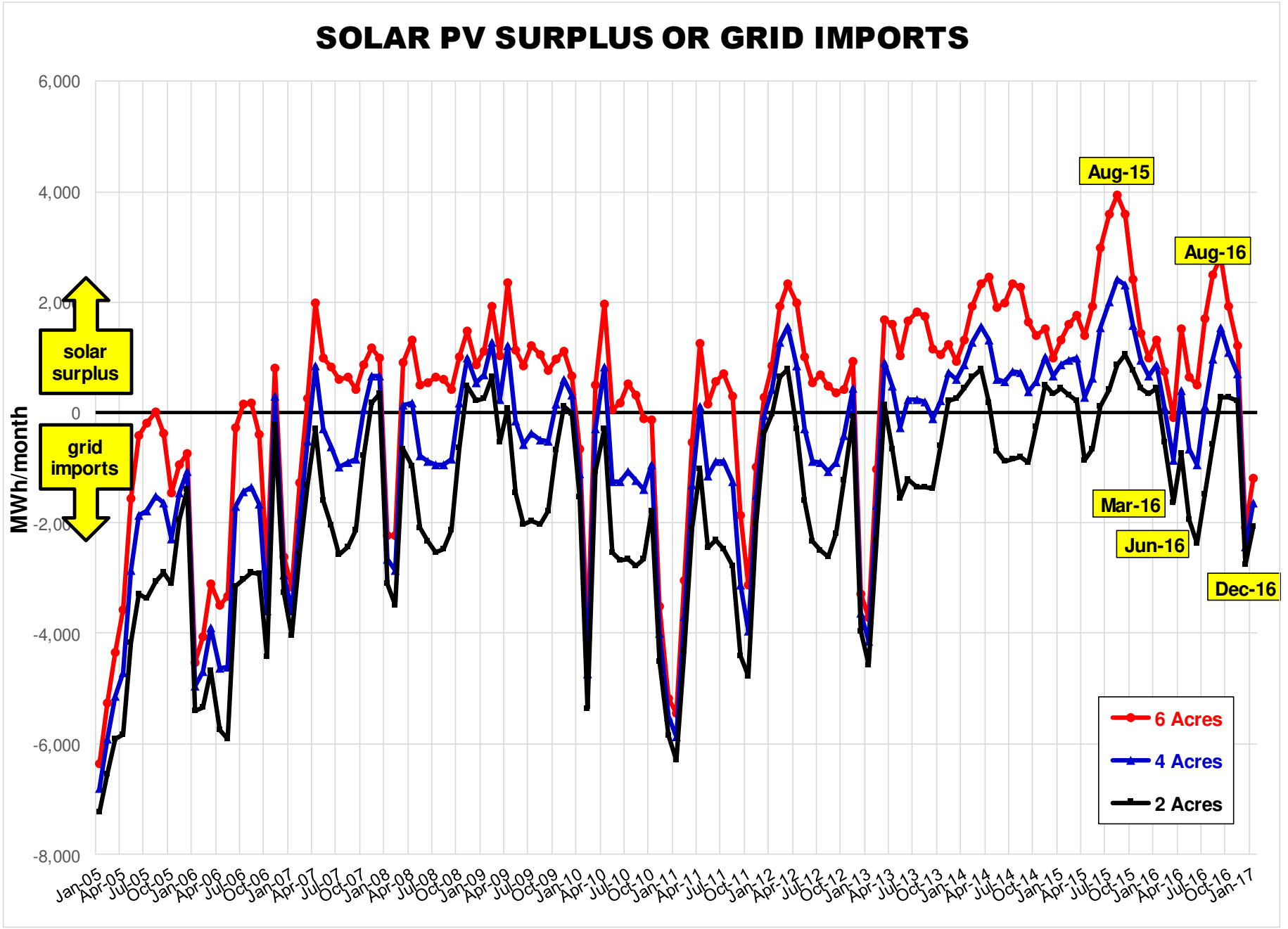




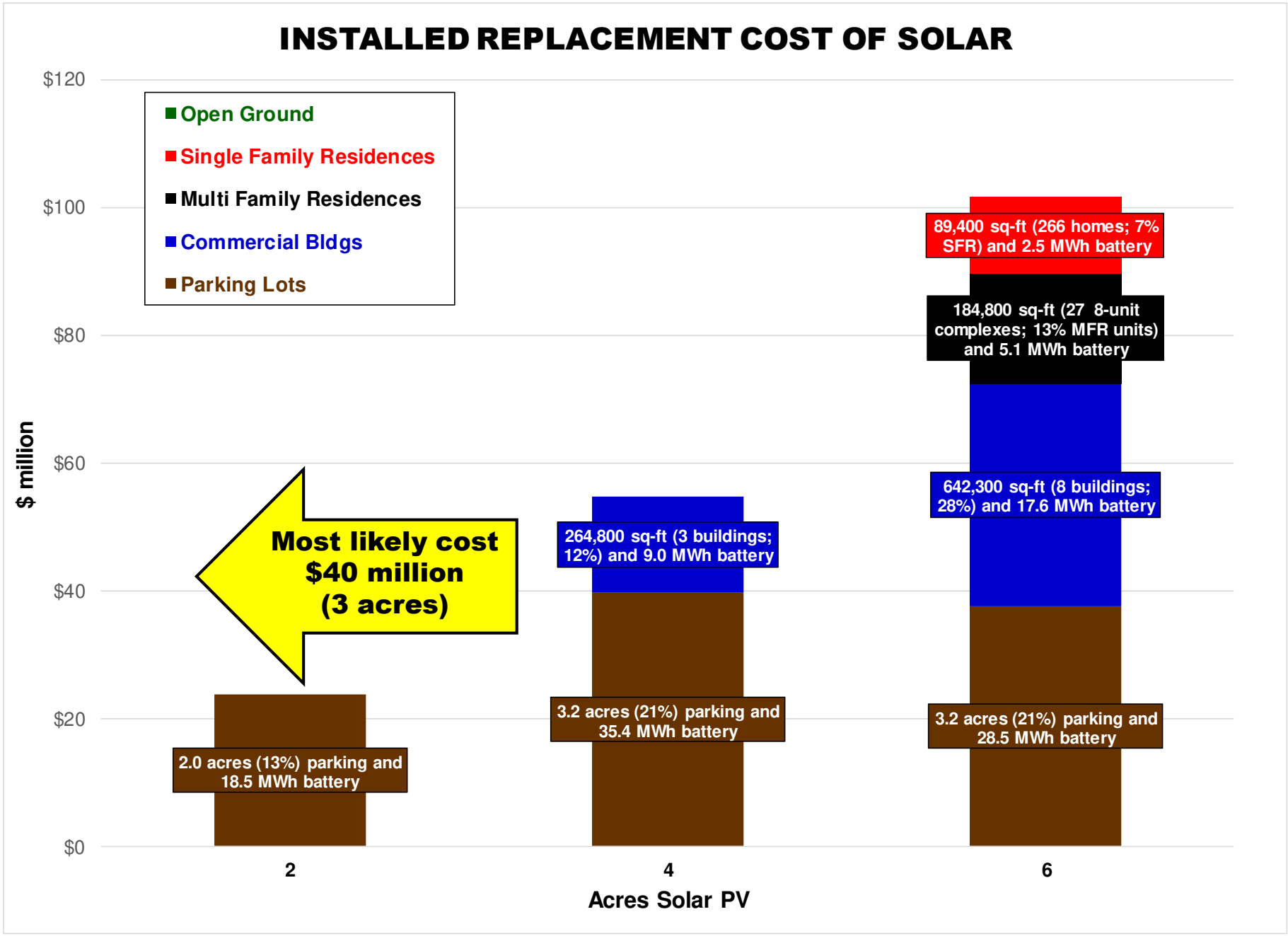
- **Based on performance data from a large (1 MW nameplate rating) in Mendocino County along the 101 corridor.**
- **Power output varies between seasons/months, and with the hour of day.**
- **The differences between min/avg/max are driven by weather/clouds.**
- **January avg operation is 8 hrs/day; August is 11 hrs/day**
- **Energy (kWh) = Daily sum of [Power (kW)] x [Operation (hrs/day]**



- **Based on performance data from a large (1 MW nameplate rating; 2011), and a small (5.5 kW nameplate rating; 2016) in Mendocino County along the 101 corridor.**
- **Max power occurs near noon (depending on collectors' azimuth and tilt angles) on clearest day of each month.**
- **Avg power and energy calculated from the sum of daily hours of operation and energy output for the whole month (both depend on weather conditions and change from year to year).**



- with 6 acres of solar PV, there would always be surplus energy – except for large winter and spring releases (e.g. Mar-16; Dec-16)
- Since 2013, 4 acres of solar PV would mostly provide a surplus – except for large winter and spring releases
- Even 2 acres of solar PV could be sufficient when combined with wind, efficiency, and load shifting – but validation requires data about supply through 5 PG&E substations along the 101 corridor.

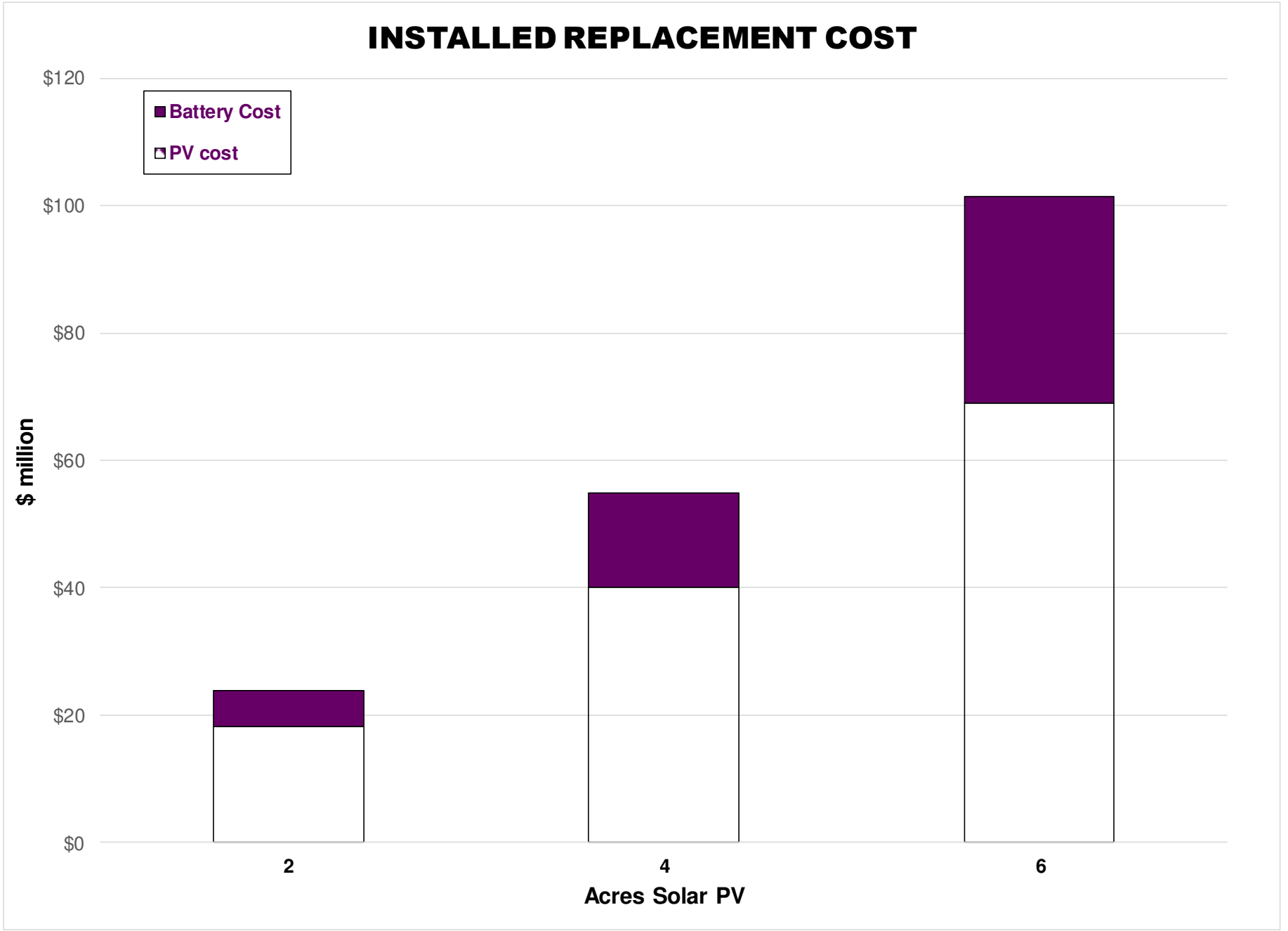


Installation priority (based on unit costs of PV and battery):

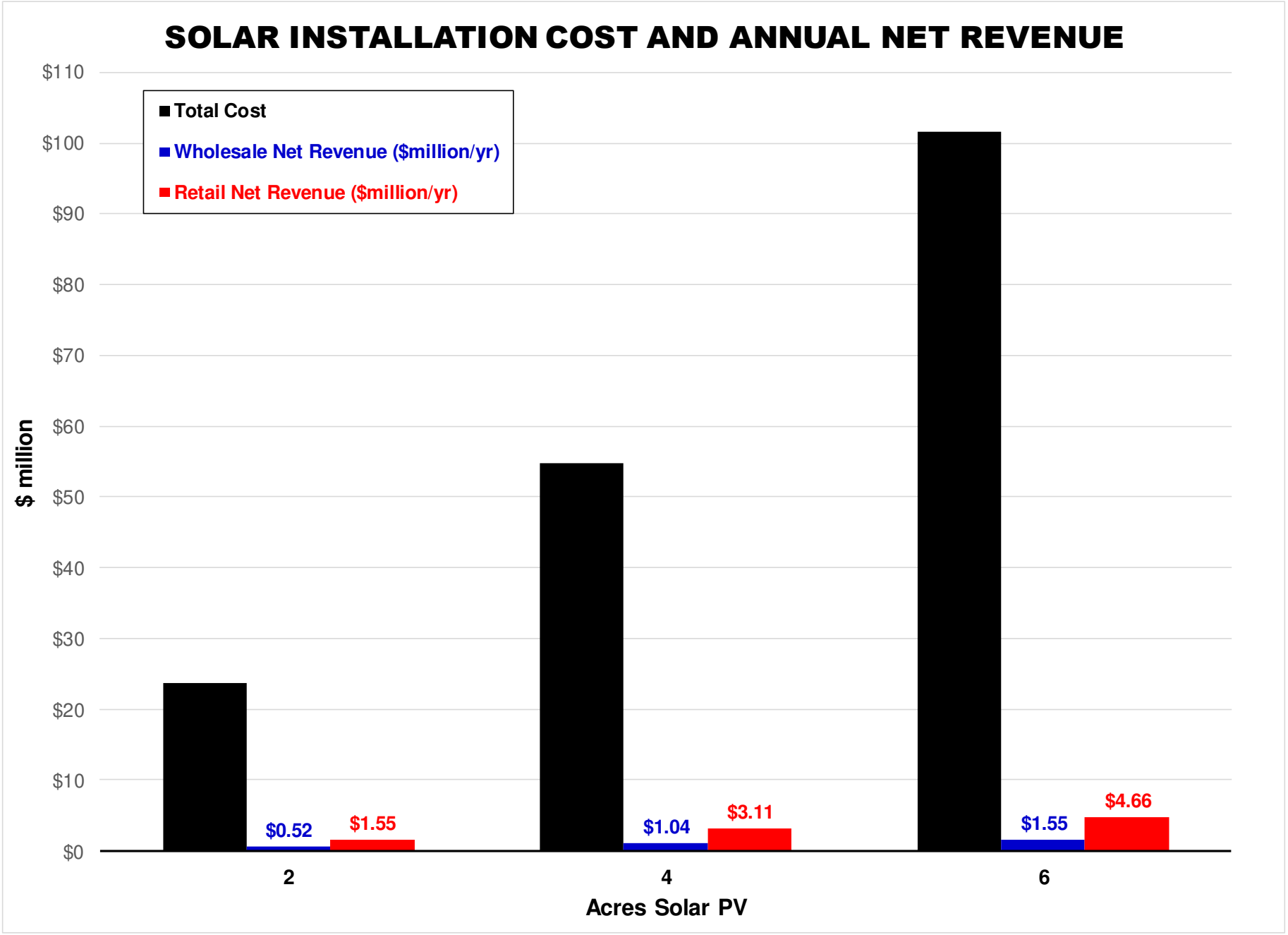
1. **Parking lots**
2. **Commercial buildings**
3. **Multi family residences**
4. **Single family residences**
5. **Open ground**

Optimal size is likely between 2-4 acres, depending on:

- **PG&E substation demand patterns i.e. how much of the hydro is actually used locally**
- **Ability to reduce and reshape local demand patterns to match solar output**
- **Non-battery, end-use storage options such as chilled water/ice and irrigation reservoirs**
- **Allowance for non damaging releases in wet months**



- **Batteries were sized to replace hydro in non-solar hours, whenever a solar surplus was calculated from Jan-13 to Dec-16 data (maximum value selected).**
- **There are practical technical limits on the size/duration of batteries. Currently batteries are usually applied to bridge gaps created by clouds or other short-term interferences.**
- **This means that every effort should be made to reduce and shift loads with non-battery, end-use storage options such as chilled water/ice and irrigation reservoirs**



- Installation cost is the capital required for the solar systems.
- Annual net revenue is the value of the solar energy at wholesale or retail electricity prices, plus any surpluses (more solar energy generated than provided by hydro) Surpluses are possible beyond 2 acres.
- At 2 acres, not enough solar energy is available to replace all the hydro. This means that electricity must be purchased from the grid to make up for the hydro, and the net revenue is smaller than for hydro.
- Net revenue from the solar will not provide a short-enough payback period to justify the investment within the expected 20 year lifetime for solar systems.
- **The hydro replacement could be justified by netting out PVP upgrade costs from the solar installation costs – and by adding the value of fisheries restoration.**

2005-2016 DATA REQUIRED TO IMPROVE ACCURACY OF RESULTS

1. Hourly end-use demand in Ukiah (City and NCPA) – or PG&E substation data
2. Hourly flow data (E16) through the PVP diversion tunnel – or confirmation from PG&E that hourly flow is constant
3. Operations parameters for PVP turbines (PG&E or FERC):
    a. Max/Min limits of flow and power – and/or known correlations
    b. Daily energy generation
4. Operations parameters for Mendocino turbines (City of Ukiah, NCPA, or FERC):
    a. Max/Min limits of flow, head, and power – and/or known correlations
    b. Daily energy generation
5. Confirmation of total number/area of urban facilities: parking lots, commercial buildings, MFR, SFR (City of Ukiah)
6. Hourly output data from 3-5 more existing solar systems, over 3-5 previous years (public agencies and schools)

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