Town of Paradise
Community Development Department
Building Division
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Off-Grid Solar Handout

This handout is intended to provide guidance for how to design off-grid solar installations that are not connected to a commercial power source and that provide an equivalent source of power to an electrical service from a commercial power source in accordance with the California Building Standards Codes. This is not an all-inclusive list of code requirements or installation examples. This is intended to provide guidance regarding these types of improvements. A building permit is required for these types of electrical improvements and approval shall be gained from the Town of Paradise Building Department prior to commencing any construction.

General

- System shall be designed by a licensed solar contractor for residential projects and a licensed electrical engineer for commercial projects.
- A 100-amp rated distribution panel and feeder conductors from the off-grid system to the distribution panel are required.
- All equipment shall be listed (UL) or by another recognized testing/listing agency.
- An electrical disconnect is required at the exterior of the structure served by the off-grid solar system.
- Plans shall be submitted based on the load calculation example included below.
- The design of the system shall meet all requirements per the most recently adopted edition of the California Electrical Code and local ordinances.

Commercial

- Systems shall be designed by an Electrical Engineer.
- Systems shall be designed to provide sufficient power for all expected loads which may include well, fire alarms, and sprinkler pumps. Load calculations and other required information is needed to determine compliance.
- Systems shall provide 3 days of autonomy.
- Systems shall include a fixed generator controlled by an automatic transfer switch.
- System shall be approved by the local fire district.

Residential and Accessory Structures

- Systems shall be designed based on daily winter electrical usage.
- Solar array output rating shall be minimum 50% of the winter daily kWh (expressed in kW) adjusted using a shading factor when trees or other obstructions limit solar access.

- Minimum battery inverter capacity: The inverter shall be rated to meet the maximum surge load and the maximum continuous loads calculated.
- Minimum battery capacity shall provide 3 days of autonomy – The battery bank shall be approved based on *available capacity* (kWh).
- A generator plug socket and designated portable generator location with gravel and/or solid pad is required. A fixed generator with an auto-start feature is optional.

Residential Plan Submittal Requirements

- Load calculation based on the example include below.
- Solar plans.
- Generator plans for fixed automatic transfer switch type generator.
- For portable generators indicate the location of the required gravel and/or solid pad, submit a generator specification sheet, and specifications for the manual transfer switch.
- Shading report which indicates the available solar access and is used to adjust the solar array output.
- Battery specification sheets including the discharge capacity.

Single Family Dwelling Minimum System Design

The California Residential Code defines a dwelling unit as "a single unit providing complete independent living facilities for one or more persons, including permanent provisions for living, sleeping, eating, cooking and sanitation". The California Electrical Code requires a minimum 100 amp electrical service and separate electrical circuits for kitchen countertops, bathrooms, laundry rooms and exterior receptables. In order to meet these minimum code requirements, it has been established 4kWh as the minimum daily winter load used for the design of off-grid systems. We recognize that members of our community may use less power and must balance this with the minimum standards listed above. It is our hope that the additional electrical capacity will provide a comfortable and usable residence for the life of the structure while not increasing the cost of the system excessively.

The minimum system design criteria is as follows:

- Winter Electrical Usage: 4kWh
- Minimum Solar Array: 2kW adjusted for shading
- Minimum Battery Storage: 12kWh based on available usable storage capacity
- Minimum Inverter Rating: 7kw

Single Family Dwelling Off-Grid Solar Compliance Example

- **Step 1:** Calculate your winter daily consumption.

  Identify all applicable loads from the list on sheet 2. Add all daily loads to determine the total daily winter consumption – see example on sheet 3.

- **Step 2:** Determine the solar array output.

  The solar array shall be greater than 50% of average daily kWh expressed in kW and shall be adjusted using a shading factor (% available average September-March).

  Example: Home has 8 average kWh daily usage, and the shading report shows 75% average sun through dark half of the year.

  Calculation: 8.0 kWh x .5= 4 array size/.75 average shading= 5.33 kW minimum DC rating for solar array**.**

- **Step 3:** Determine the required battery bank kWh capacity based on a minimum 3 days of autonomy and the available battery storage capacity based on battery type/chemistry and charge controller settings.

- **Example:** Total daily winter consumption x 3 day of autonomy / maximum battery discharge = battery bank capacity.

  Calculation: Total Daily Consumption: 8 kWh x 3 Days Autonomy =24 kWh/.75 maximum battery discharge = 32 kWh.

Typical Loads for Residential Off-grid Solar Design

Appliance	Watts	Surge	Hours/Mo	Hours/Day
Air Conditioner (Room) 6,000 BTU	750	1300	120 – 360	3 – 18.3
Air Conditioner (Central) 2.5 Tons	3500	7000	240 -540	0.3 - 1.6
AV Rack	4500	4500	360--720	12--24
Ceiling Fan	65	65	15 – 730	0.3 - 1.6
Clock	5	5	730	1.3
Clothes Dryer	3000	4500	6 – 28	0.6 - 2.8
Clothes Washer, Automatic (With Electric Water Heating)	1800	3600	7 -40	0.4 - 2.4
Clothes Washer, Automatic (With Non-Electric Water Heating)	500	1000	7 – 47	0.1 - 0.6
Coffee Maker	900	900	4 – 30	0.1 - 0.9
Computer (Monitor & Printer)	200	200	25 – 160	0.2 - 1.1
Crock Pot	250	250	8 – 24	0.1 - 0.2
Dehumidifier	350	500	120 – 730	1.4 - 8.5
Dishwasher (With Electric Water Heating)	1500	3000	8 – 40	0.4 - 2
Electric Blanket	180	180	30 – 90	0.2 – 0.5
Electric Heater (Portable)	1200	1200	30 – 90	1.2 – 3.6
Front Gates (single)	30	80	1 - 1.2	0.02 - 0.1
Front Gates (double)	60	160	1 - 1.2	0.02 - 0.1
Food Blender	390	390	3 – 5	0.03 – 0.07
Food Freezer (15 cu. Ft.)	335	700	180 – 420	2 – 4.7
Furnace Fan Blower 1/2 hp	800	2350	160 – 415	1.9 – 4.8
Furnace Fan Blower 1/3 hp	700	1400	730	8.5 – 0
Garage Door opener	650	1200	1 - 1.2	0.02 - 0.1
Hair Dryer	1200	1200	15 – 30	0.03 – 0.07
Heating Pad	80	80	250 – 500	1.7 – 3.3
Heat Pump	4700	10000	150-360	23.5 – 56.4
Humidifier (13 Gal)	175	175	80 – 540	0.3 – 1.8
Iron (Hand)	1000	1000	1 – 10	0.03 – 0.3
LED lighting (per bulb)	10	10	6-195	0.03 - 1.2
LED Fixtures (4 ft fixture)	30	30	6-195	0.03-1.2
Lighting Single Lamp (60W)	60	60	17 – 200	0.03 – 0.4
Compact Fluorescent (60W Equiv)	18	18	17 – 200	0.1 – 0.1
Ceiling Fixture (3 bulbs)	180	180	6 – 195	0.03 – 1.2
Table Lamp	100	100	10 – 200	0.03 – 0.7
Fluorescent (2 Tube 4 ft)	100	125	10 -200	0.03 – 0.7
Microwave Oven	1000	1000	5 – 30	0.2 – 1
Minisplit AC	2000	5000	90 – 120	7.5 – 8
Minisplit Heat	2500	6000	90 – 120	7.5 – 8
Range (Electric)	1300	1300	10 – 50	4.2 – 20.8
Range (Self Cleaning Cycle Only)	3200	3200	1	0.1 – 0
Refrigerator – Freezer Frost Free (17 cu. Ft.)	400	1200	150 – 300	5 – 5
Sump Pump at 1/2 hp	1000	2200	90-150	3 – 5
Sump Pump at 1/3 hp	800	1300	90-150	3 – 5
Television	400	400	30-60	0.4 – 0.8

Winter Daily Consumption Example

Sizing Tool										
(1) Daily Load							Winter			
#	Item		Power		Surge		Hrs. per Day		Consumption	
0	All Loads:	On	7027	W	12370	W	Avg. 1.08	h	7.56	kWh
1	refer	1	600	W	1000	W	6	h	3.6	kWh
2	Micro/Hood	1	800	W	800	W	0.1	h	0.08	kWh
3	solar well pump			W		W		h	0	kWh
4	Fire sprinkler pump			W		W		h	0	kWh
5	Dishwasher	1	900	W	1500	W	0.5	h	0.45	kWh
7	Washer	1	450	W	900	W	0.75	h	0.338	kWh
8	Gas Dryer	1	450	W	900	W	0.75	h	0.338	kWh
9	Ceiling Fan w/ Light (master)	1	40	W	40	W	2	h	0.08	kWh
10	Ceiling Fan w/ Light (living)	1	40	W	40	W	4	h	0.16	kWh
11	Ceiling Fan w/ Light (Bed 2)	1	40	W	40	W	1	h	0.04	kWh
12	Chandelier	1	60	W	60	W	1	h	0.06	kWh
13	Pendant Light	3	20	W	20	W	2	h	0.12	kWh
14	6" recessed light	5	12	W	12	W	3	h	0.18	kWh
15	2-Light Vanity	1	30	W	30	W	0.5	h	0.015	kWh
16	Light/Vent in bath	2	25	W	25	W	0.25	h	0.013	kWh
17	Smoke Detectors	1	5	W	5	W	24	h	0.12	kWh
18	Carriage porch light	1	25	W	25	W	2	h	0.05	kWh
19	Router	1	30	W	30	W	24	h	0.72	kWh
20	3 ton AC	1	3500	W	7000	W	0	h	0	kWh

Total Daily Consumption - 7.75 kWh 3 Days Autonomy - 23.25 kWh Battery Bank Capacity - 30 kWh