SOLAR POWER BY THE NUMBERS

Grid-tie and Off-grid solar systems

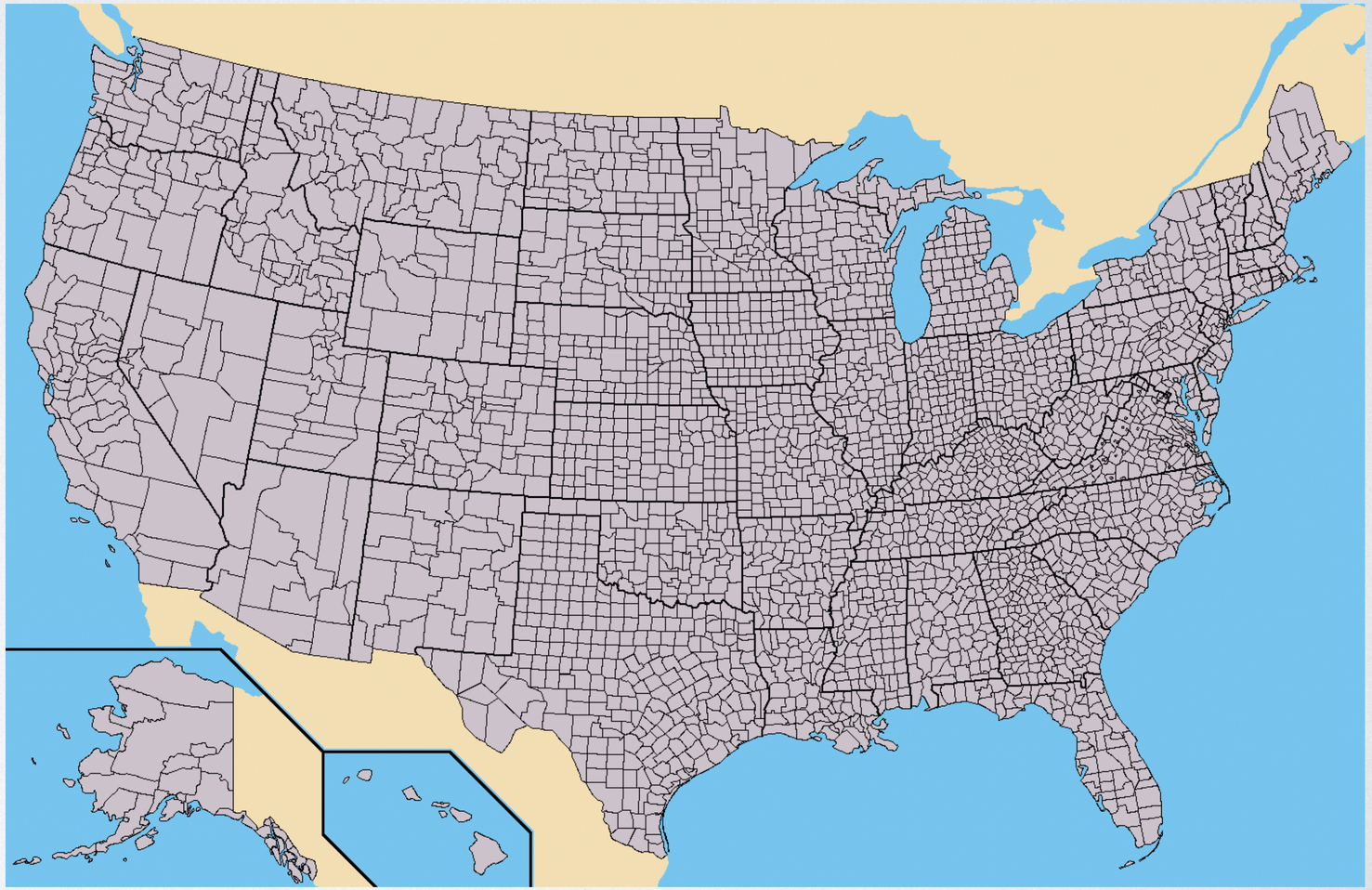
By Ryan Booth

2 RULES

- #1 Do your own research
- #2 What is your time worth?
- I'm probably wrong

LOCAL RULES

- 50 States
- 3,143 Counties
- 19,502 Incorporated Cities
- 29,705 Fire Departments
- 3,300 Utilities (200 major)



Power and Energy

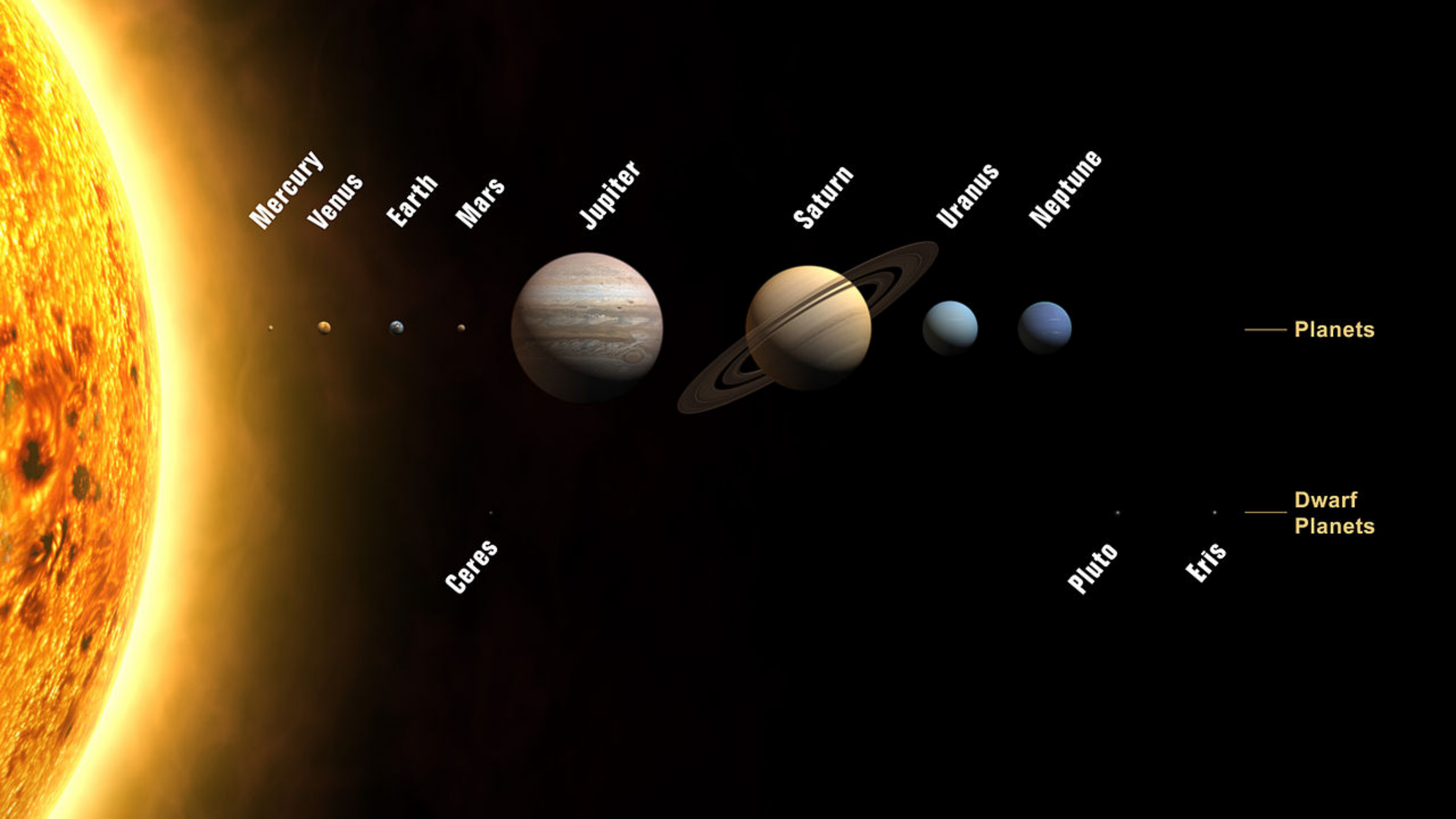
Watts = Amps x Volts

1000 watts = 1 kilowatt (kW)

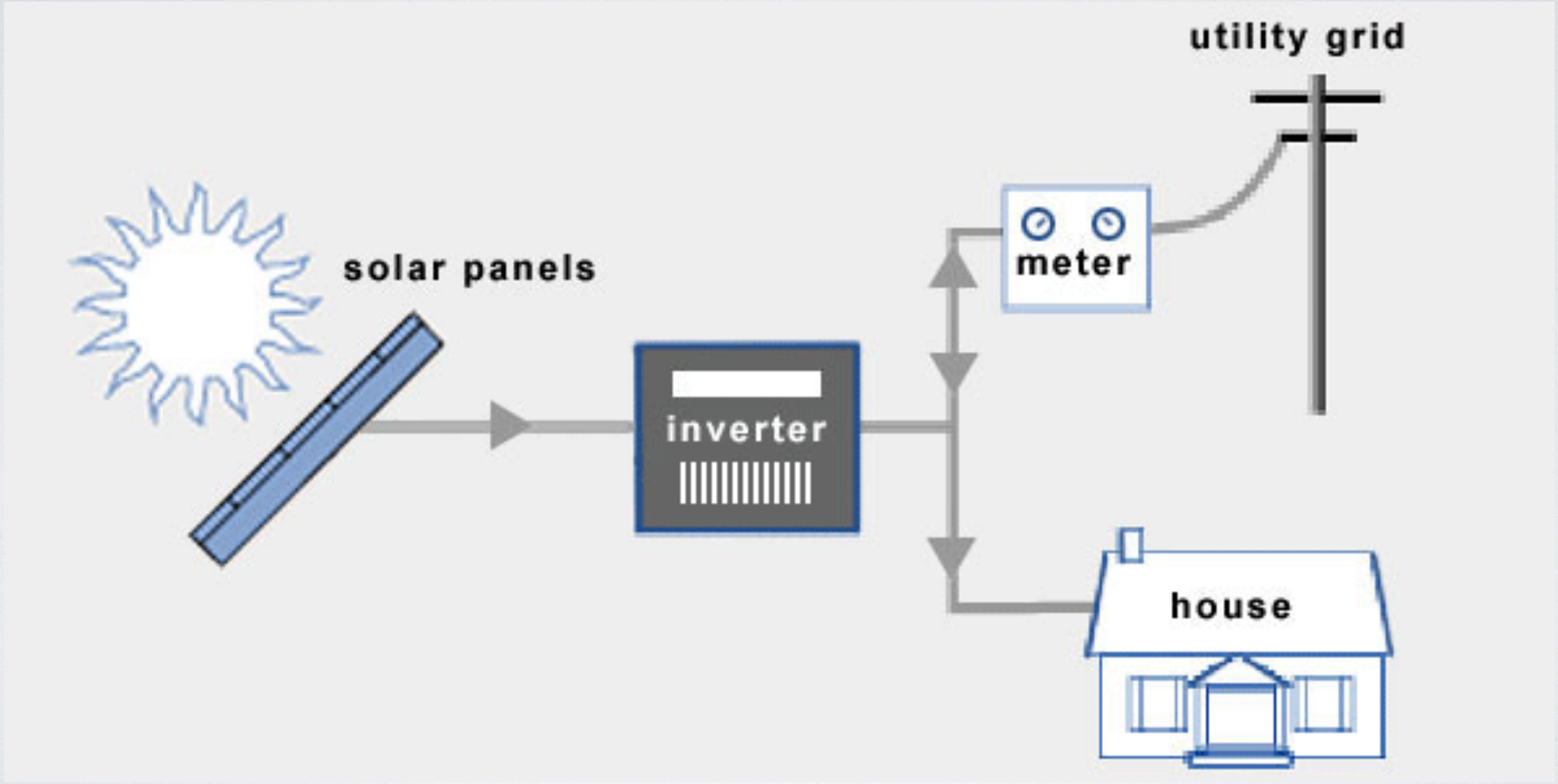
Kilowatt Hours (kWh)

30 amps x 50 volts = 1500 watts (1.5 kW)

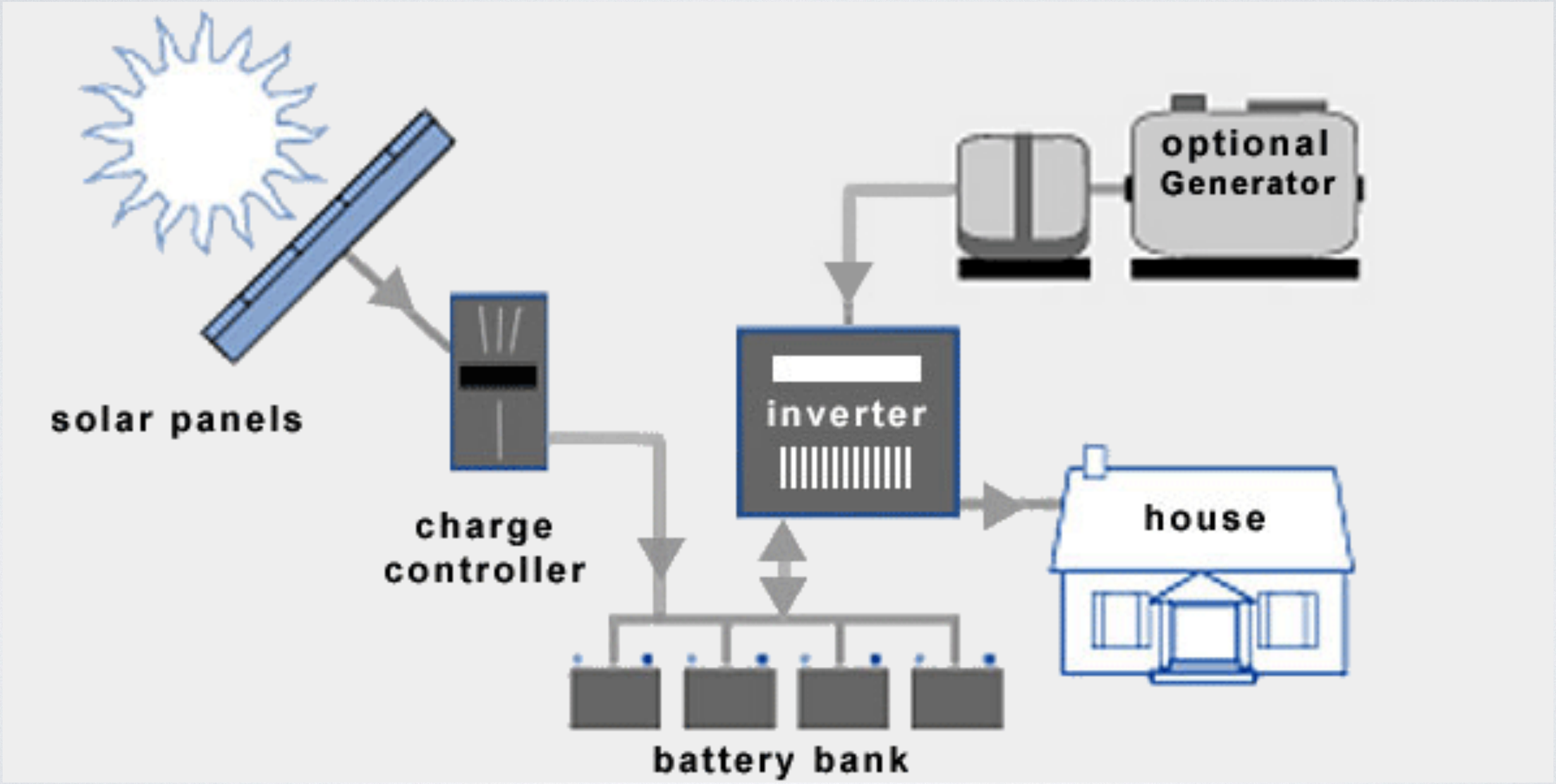
220 volts x 6.25 amps = 1.5 kW


Mercury
Venus
Earth
Mars
Jupiter
Saturn
Uranus
Neptune
Planets
Ceres
Pluto
Eris
Dwarf Planets

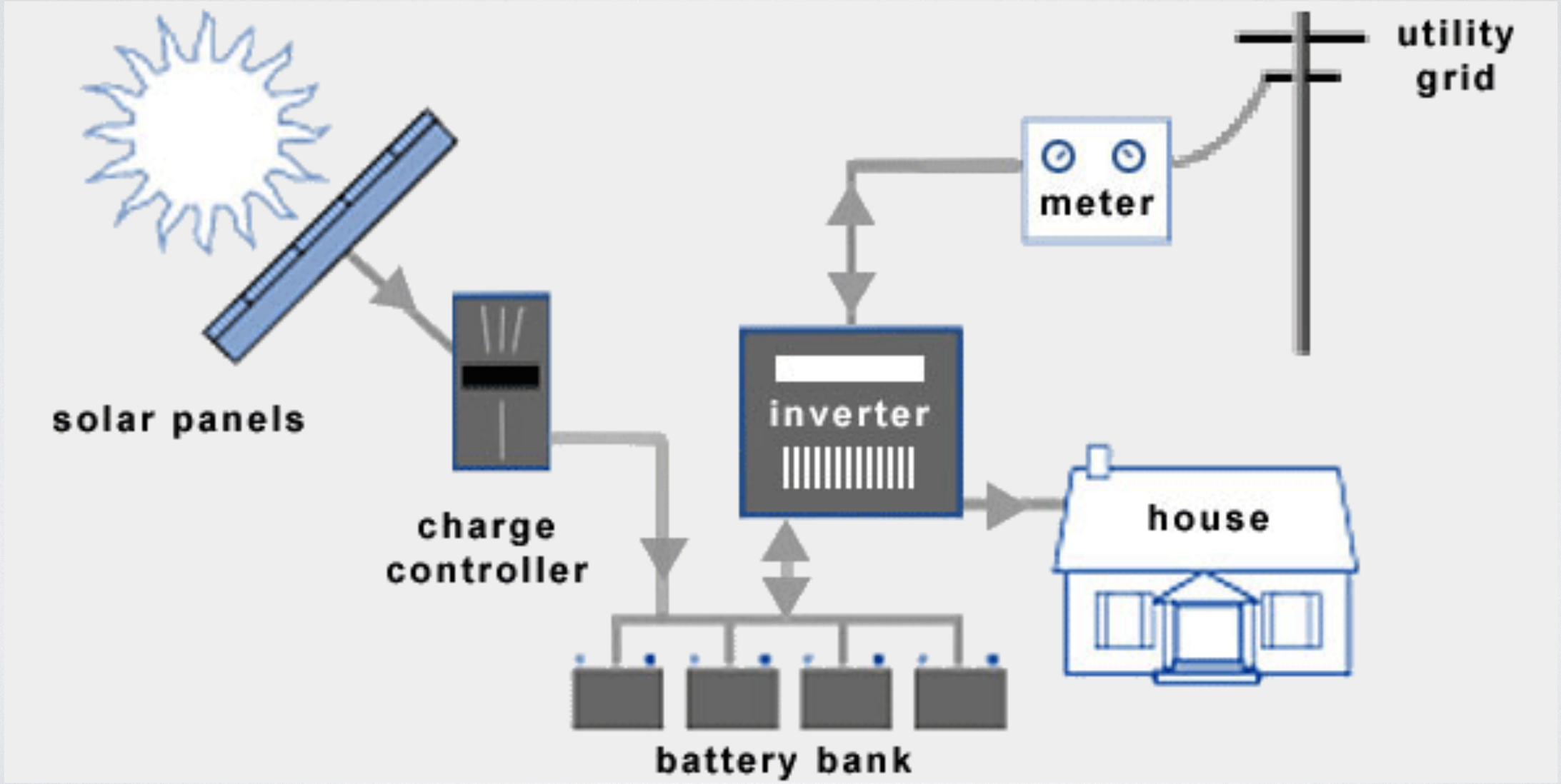
What is a Grid-tied Solar system?



Whats is an Off-grid Solar System?



What is a Hybrid Solar System?

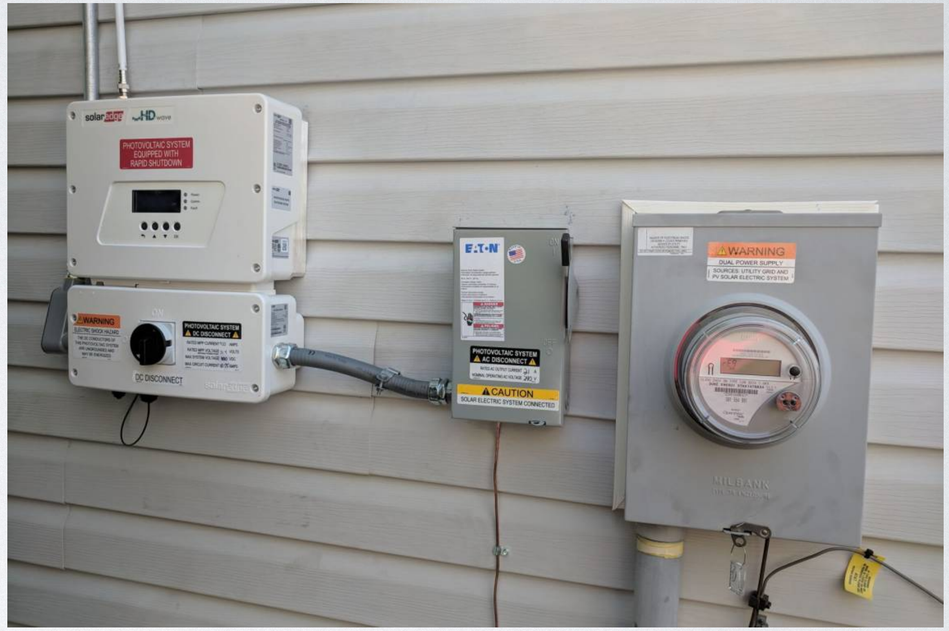


Grid-tie Parts Cost

- Panels $0.65 - $1 per watt
- Roof top racking $0.20 per watt
- Ground mount racking $0.60+ per watt
- Grid-tie inverter $0.20 per watt
- Optimizers $0.15 - $0.25 per watt
- Wiring and everything else $0.10 per watt
- Total $1.30 to $2.15 per watt
- Plans $400+

Sample Grid-tie system

22 - 365w panels (8,030w)
with
Racking and Optimizers
$9,636



Inverter and assorted wiring
$2000

Plans, permits and fees $1,100

Total cost $12,736

pvwatts.nrel.gov

SYSTEM INFO

Modify the inputs below to run the simulation.

DC System Size (kW):	8
Module Type:	Standard
Array Type:	Fixed (open rack)
System Losses (%):	14.08
Tilt (deg):	20
Azimuth (deg):	180

Loss Calculator

+ Advanced Parameters

RETAIL ELECTRICITY RATE

To automatically download an average annual retail electricity rate for your location, or commercial). You can change the rate to use a different value by typing a differen

Rate Type:	Residential
Rate ($/kWh):	.30

pvwatts.nrel.gov

RESULTS

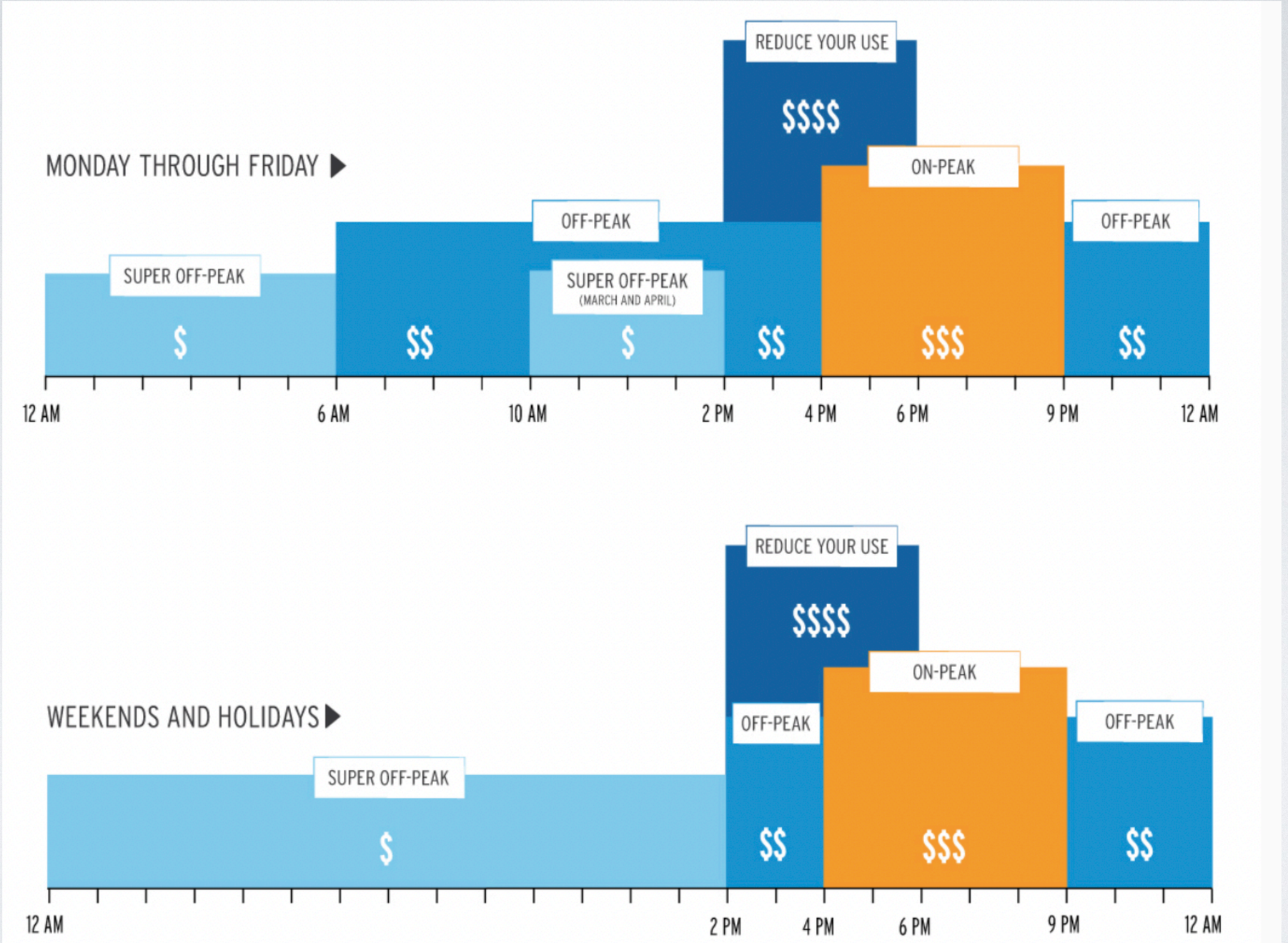
Print Results

13,424 kWh/Year*

System output may range from 12,903 to 13,509 kWh per year near this location.

*Click **HERE** for more information.*

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	4.65	870	348
February	4.99	850	340
March	6.38	1,183	473
April	6.83	1,217	487
May	7.18	1,278	511
June	7.80	1,333	533
July	7.62	1,347	539
August	7.55	1,323	529
September	6.90	1,188	475
October	6.01	1,095	438
November	5.02	895	358
December	4.44	846	338
Annual	6.28	13,425	$ 5,369


MONDAY THROUGH FRIDAY
REDUCE YOUR USE
$$$$
ON-PEAK
OFF-PEAK
OFF-PEAK
SUPER OFF-PEAK
SUPER OFF-PEAK
(MARCH AND APRIL)
$
$$
$
$$
$$$
$$
12 AM
6 AM
10 AM
2 PM
4 PM
6 PM
9 PM
12 AM
WEEKENDS AND HOLIDAYS
REDUCE YOUR USE
$$$$
ON-PEAK
OFF-PEAK
OFF-PEAK
SUPER OFF-PEAK
$
$$
$$$
$$
12 AM
2 PM
4 PM
6 PM
9 PM
12 AM

What does your power cost?

SCHEDULE DR-SES										Schedule WF-NBC + DWR-BC Rate	Schedule EECC + DWR Credit Rate	Total Electric Rate
Energy Charges ($/kWh)	**Transm**	**Distr**	**PPP**	**ND**	**CTC**	**LGC**	**RS**	**TRAC**	**UDC Total**			
Summer												
On-Peak	0.07248	0.13991	0.01851	0.00007	0.00110	0.00390	0.00001	0.00000	0.23598	0.00652	0.40908	0.65158
Off-Peak	0.07248	0.13991	0.01851	0.00007	0.00110	0.00390	0.00001	0.00000	0.23598	0.00652	0.15058	0.39308
Super Off-Peak	0.07248	0.13991	0.01851	0.00007	0.00110	0.00390	0.00001	0.00000	0.23598	0.00652	0.07083	0.31333
Winter												
On-Peak	0.07248	0.13991	0.01851	0.00007	0.00110	0.00390	0.00001	0.00000	0.23598	0.00652	0.17388	0.41638
Off-Peak	0.07248	0.13991	0.01851	0.00007	0.00110	0.00390	0.00001	0.00000	0.23598	0.00652	0.12470	0.36720
Super Off-Peak	0.07248	0.13991	0.01851	0.00007	0.00110	0.00390	0.00001	0.00000	0.23598	0.00652	0.06442	0.30692
Other Charges/Discounts												
Metering Charge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Minimum Bill	0.000	0.350	0.000	0.000	0.000	0.000	0.000	0.000	0.350	0.000	0.000	0.350

The total rates presented reflect the UDC rates associated with service under Schedule DR-SES and the generation rates associated with Schedules EECC and DWR-BC. The UDC rate-by-rate components presented are associated with service under Schedule DR-SES as presented in the utility's tariff book.

Average Rate = $0.40kWh

Schedule D - Residential and Commercial

	Basic Charge	Energy Charge	500 kwh	1000 kwh	1500 kwh	3000 kwh
Old Rate	$15.00 MIN	$0.082	$56.00	$97.00	$138.00	$237.00
Current Rate	$15.00 MIN	$0.085	$57.50	$100.00	$142.50	$261.00
Monthly Increase	0	$0.003	$1.50	$3.00	$4.50	$24.00

Schedule OL - Outdoor Lighting

	No Change
9,500 lumen (100w)	$6.50/light
22,000 lumen (200w)	$8.50/light

Basic Facility Charge will be calculated at a rate of $1/kva transformer size, with a minimum of $15.00 per month. All kilowatts will be charged at the current rate.

Schedule PA - Agricultural Irrigation Service

	Basic Load Charge	Energy Charge	50 hp-1500 hrs	100 hp-1500 hrs	150hp-1500 hrs	200hp-1500 hrs
Old Rate	$2.67/hp/mo	$0.0665	$4,935.64	$9,871.28	$14,806.91	$19,742.55
Current Rate	$2.67/hp/mo	$0.0695	$5,122.16	$10,244.33	$15,366.49	$20,488.65
Annual Increase	0	$0.003	$186.52	$373.05	$559.58	$746.10

Stock Water Rate

	Old Rate	New Rate
Basic Charge	$15.00 MIN	$15.00 MIN
All Energy	$0.093	$0.096

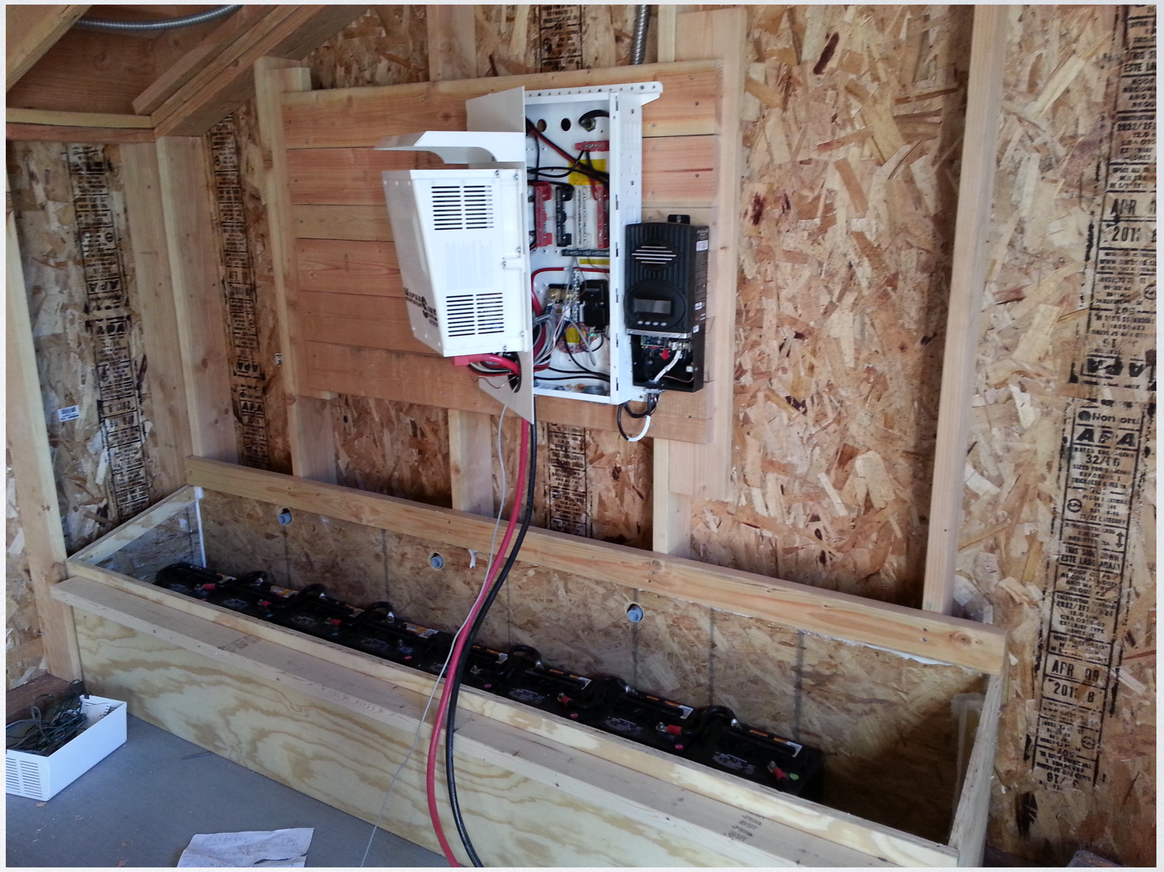
Average rate $0.08kWh

- $12,736 system parts cost ($22,000 contract price)
- $12,736 - 26% federal tax credit = $9,425
- 13,400 kWh per year - off setting $0.40 per kWh = $4500
- Pay back about 2 years
- Same system at $0.08 per kWh - off setting $900
- Pay back about 10 years

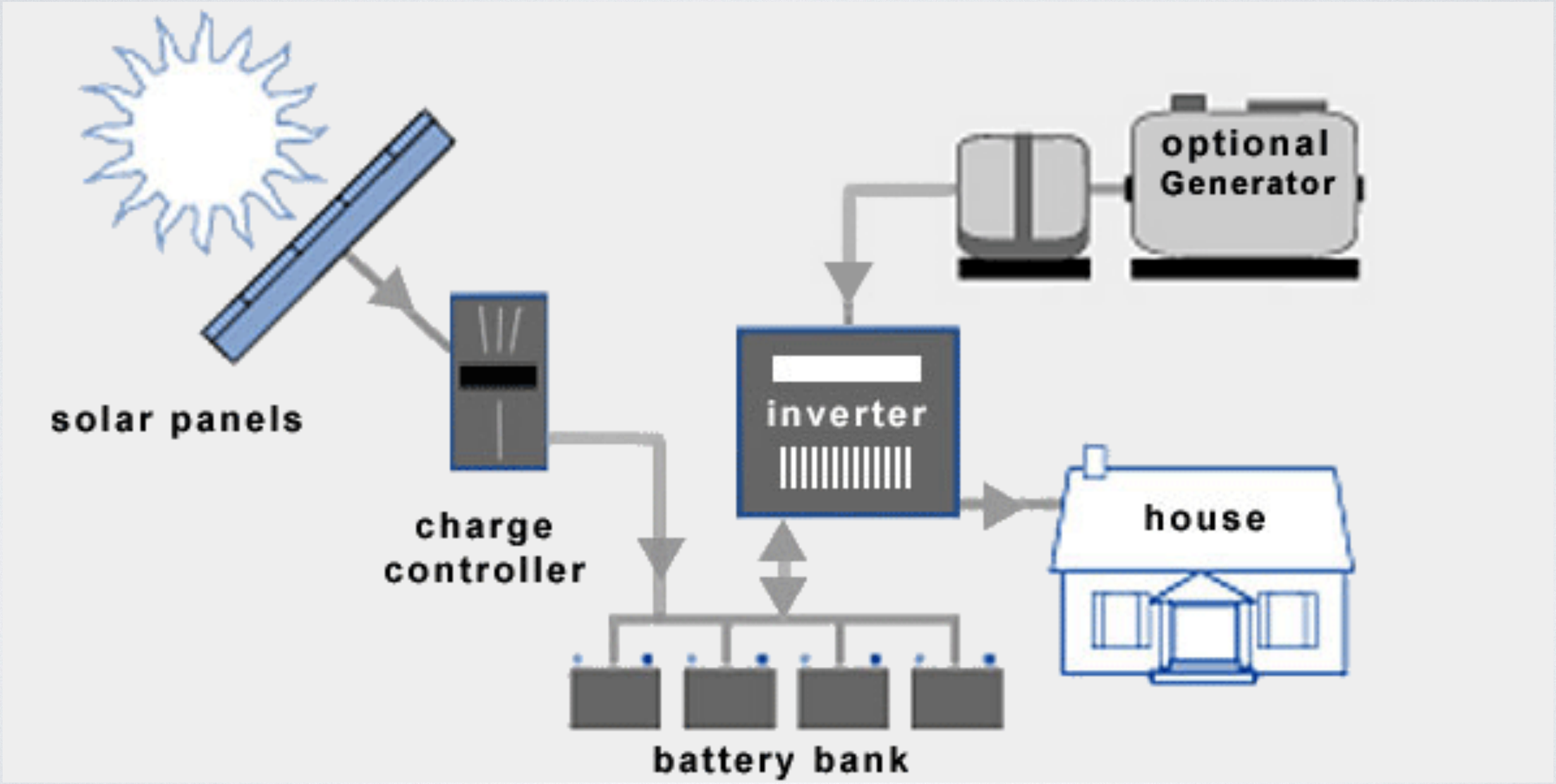
Grid-tie summery

- How much power do you use? kWh per month
- What does it cost? Cents per kWh
- Where are you located?
- Does your utility have net metering/feed in tariff etc?

Off-grid solar systems



Off-grid Solar System



Off-grid daily energy needs

Typical house

Refrigerator - 2 kWh
Small Kitchen Appliances - 2 kWh
Lights - 1 kWh
Tech - 2 kWh
Washer/Dryer - 1 kWh per load
Gas furnace - 3 kWh in Winter
Freezer - 2 kWh
Other - 2kWh

Unusual items

Air Conditioning - 5 -15 kWh
Electric Hot Water Heater - 15kWh
Cold room - 12 kWh

Water pumping -1.5 kWh per 1000 gallons at 100 ft of head
Water pressurizing - 1.5 kWh per 1000 gallons at 50PSI

Total 18kWh per day - 560kWh per month

Sandpoint, ID

12kW Solar Array - $14,400

RESULTS

Print Results

14,036 kWh/Year*

System output may range from 13,465 to 14,644 kWh per year near this location.

Click HERE for more information.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	1.71	535	N/A
February	2.85	797	N/A
March	3.81	1,113	N/A
April	5.22	1,427	N/A
May	5.95	1,624	N/A
June	5.94	1,541	N/A
July	7.27	1,883	N/A
August	6.88	1,749	N/A
September	5.27	1,375	N/A
October	3.40	967	N/A
November	1.83	529	N/A
December	1.60	496	N/A
Annual	4.31	14,036	0

8kW Solar Array - $9,600

RESULTS

Print Results

9,357 kWh/Year*

System output may range from 8,977 to 9,763 kWh per year near this location.

Click HERE for more information.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	1.71	357	N/A
February	2.85	532	N/A
March	3.81	742	N/A
April	5.22	952	N/A
May	5.95	1,083	N/A
June	5.94	1,027	N/A
July	7.27	1,255	N/A
August	6.88	1,166	N/A
September	5.27	917	N/A
October	3.40	645	N/A
November	1.83	353	N/A
December	1.60	331	N/A
Annual	4.31	9,360	0

6 kW Solar Array - Wilcox, AZ - $7,200 - 6 kW Solar Array - Tulsa, OK

RESULTS

Print Results

10,724 kWh/Year*

System output may range from 10,138 to 10,814 kWh per year near this location.

Click HERE for more information.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	5.17	760	N/A
February	6.11	787	N/A
March	7.28	1,005	N/A
April	7.83	1,042	N/A
May	8.07	1,087	N/A
June	7.94	989	N/A
July	6.89	890	N/A
August	7.04	906	N/A
September	6.88	875	N/A
October	6.45	878	N/A
November	5.71	767	N/A
December	5.07	739	N/A
Annual	6.70	10,725	0

RESULTS

Print Results

8,697 kWh/Year*

System output may range from 8,409 to 8,903 kWh per year near this location.

Click HERE for more information.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	3.92	595	N/A
February	4.36	592	N/A
March	5.06	725	N/A
April	5.84	790	N/A
May	6.10	833	N/A
June	6.74	871	N/A
July	6.75	883	N/A
August	6.52	849	N/A
September	6.02	784	N/A
October	4.99	696	N/A
November	4.01	564	N/A
December	3.40	514	N/A
Annual	5.31	8,696	0

Batteries

- Capacity
- Cycles
- Depth of Discharge (DOD)
- Types: Lithium/Lead Acid/AGM
- 36 kWh battery bank for our sample system

Calculating lifetime battery cost
Lead Acid Batteries

Trojan SPRE 06 415 - $156 per kWh

Capacity 400 Amp hours at 6 volts = (2.4 kWh)

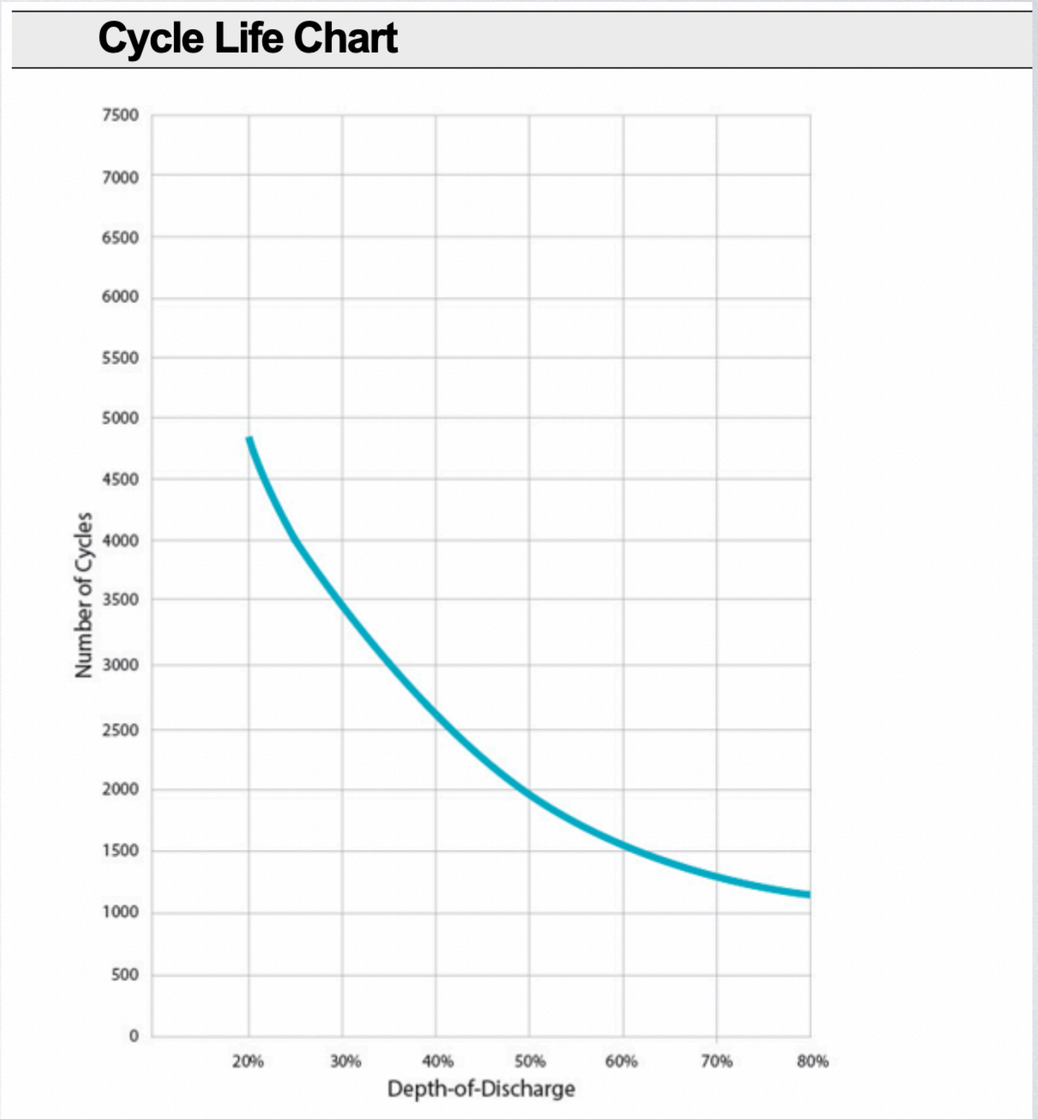
Cycles 1200 at 80% DOD

2.4 kWh x 0.8 = 1.92 usable kWh

1.92 x 1200 cycles = 2,304 life time kWh's

Price per battery $375 ÷ 2,304 = **$0.16.2 per kWh**

16 batteries = 38 kWh, Cost for battery bank, $6000



Lithium Batteries
eVault Max 18.5kWh LFP Battery - $702 per kWh

Capacity 18.5 kWh x 0.8 = 14.8 kWh

Cycles 6,000 at 80% DOD

14.8 x 6,000 = 88,800 kWh

Cost per battery $13,000 ÷ 88,800 = **$0.14.6 per kWh**

Cost for 36 kWh battery bank $26,000

Table 1.0 –Total Energy Throughput According to Maximum Depth of Discharge (DOD) for each Fortress product.

Fortress Battery Model	80% DOD	90% DOD	100% DOD
eVault 18.5 (48V)	87.2 MWH	48.9 MWH	36.3 MWH

Sample System “The Cabin” in Michigan

Daily Power Use

Refrigerator 1.5 kWh
Tech 0.5 kWh
Lights 0.2 kWh
Water pumping 1 kWh
Other 1 kWh

Total 4.2 kWh

2 kW Solar Array

RESULTS

Print Results

2,591 kWh/Year*

System output may range from 2,493 to 2,688 kWh per year near this location.
Click HERE for more information.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	2.34	128	N/A
February	3.73	182	N/A
March	5.42	277	N/A
April	5.76	276	N/A
May	5.81	276	N/A
June	5.77	262	N/A
July	6.36	290	N/A
August	5.93	271	N/A
September	4.95	223	N/A
October	3.59	177	N/A
November	2.39	119	N/A
December	2.07	110	N/A
Annual	4.51	2,591	0

System Cost

2 kW Solar Array - $2,400
9.6 kWh battery bank - $1,500
Inverter - Midnite Solar MN3024DIY - 3000 watts $600
Additional MPPT charger controller $330
E-panel and wiring $500
Honda 2200 watt Generator $1,200 (6 kWh per gallon)
Total $6,530

Alternative Inverter setup
2500 watt inverter - $1400
80 amp charge controller $600
E-panel and wiring $900
Total $8,000

Sample System - Typical House in Prescott, AZ

Daily Power Use
18 kWh

RESULTS

Print Results

13,536 kWh/Year*

System output may range from 13,081 to 13,801 kWh per year near this location.
Click HERE for more information.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	4.95	972	N/A
February	5.56	954	N/A
March	6.69	1,238	N/A
April	7.57	1,377	N/A
May	7.77	1,405	N/A
June	7.91	1,327	N/A
July	6.61	1,148	N/A
August	5.93	1,042	N/A
September	6.35	1,078	N/A
October	6.37	1,137	N/A
November	5.46	991	N/A
December	4.42	867	N/A
Annual	6.30	13,536	0

8kW Solar Array - $9,600
Inverter SolArk 12kW - $6,900
Battery bank lithium - 2 Fortress 18.5 - $26,000
Wiring etc. $1,500
Generator - $1,000 - $5,000
Total $45,000 + Plans/Tax/Shipping $6300

Total $51,300 - tax credit $13,338
After credit Total $37,962

Contract Price - $85,000

Alternative Battery bank
16 - Trojan L-16 - $6,000

Sample System - Large house in Sandpoint ID

Daily Power Use
60 kWh

RESULTS

Print Results

48,003 kWh/Year*

System output may range from 46,049 to 50,081 kWh per year near this location
Click HERE for more information

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	1.88	1,981	N/A
February	3.05	2,877	N/A
March	3.95	3,883	N/A
April	5.18	4,800	N/A
May	5.75	5,333	N/A
June	5.66	4,991	N/A
July	7.00	6,177	N/A
August	6.83	5,899	N/A
September	5.43	4,793	N/A
October	3.62	3,470	N/A
November	1.99	1,935	N/A
December	1.79	1,864	N/A
Annual	4.34	48,003	0

40 kW Solar Array $48,000

Inverter 2- SolArk 12kW - $13,800

Battery2 Bank lithium - 6 Fortress 18.5kWh - $78,000

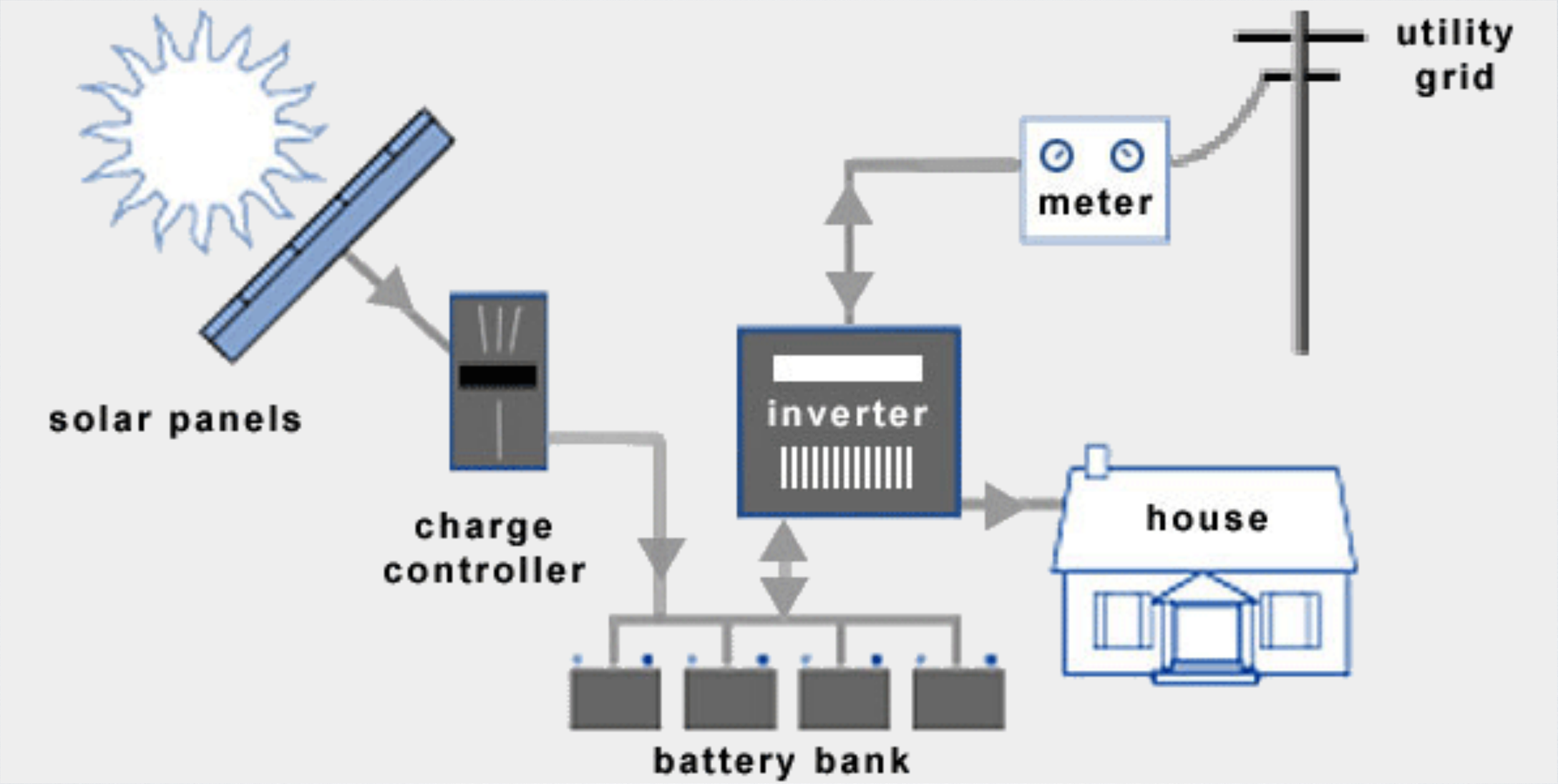
Wiring etc. $4,000

Generator $7,000-$10,000 (10 - 12 kWh per gallon)

Total $150,800 + Plans/Tax $14,840
Total 165,640 - tax credit $43,066 = $122,574

Contract Price $210,000
Alt. Lead Acid battery bank - $18,750

Hybrid Grid-tie and Off-grid



Hybrid System - Typical House in Prescott, AZ

Daily Power Use
18 kWh

8kW Solar Array - $9,600 (Makes 36kWh per day)
Inverter SolArk 12kW - $6,900
Battery bank lithium - 1-Fortress 18.5 - $13,000
Wiring etc. $1,500
Generator - $1,000 - $5,000
Total $32,000

Alternative Battery bank
16 - Trojan L-16 - $6,000

Sub-panel $1000
Plans/Permits/Fees $1200
Shipping $1200
Sales Tax $2800

Total $38,200

26% federal tax credit $9,932

Total after credit $28,268

Alternative Back-up Power

Generator $900
5-5 gallon Fuel cans for $100
Plug/cable and breaker $150

Total $1,150

4-5 kWh per gallon

Resources:

pvwatts.nrel.gov

www.solar-electric.com

QUESTIONS?