CalculationSolar.com

HELPS YOU TO CALCULATE, OF RAPID AND EASY WAY, AN ISOLATED PHOTOVOLTAIC SOLAR, LOCATED IN ANY PART OF PLANET.

FREE ONLINE APPLICATION OF CALCULATION

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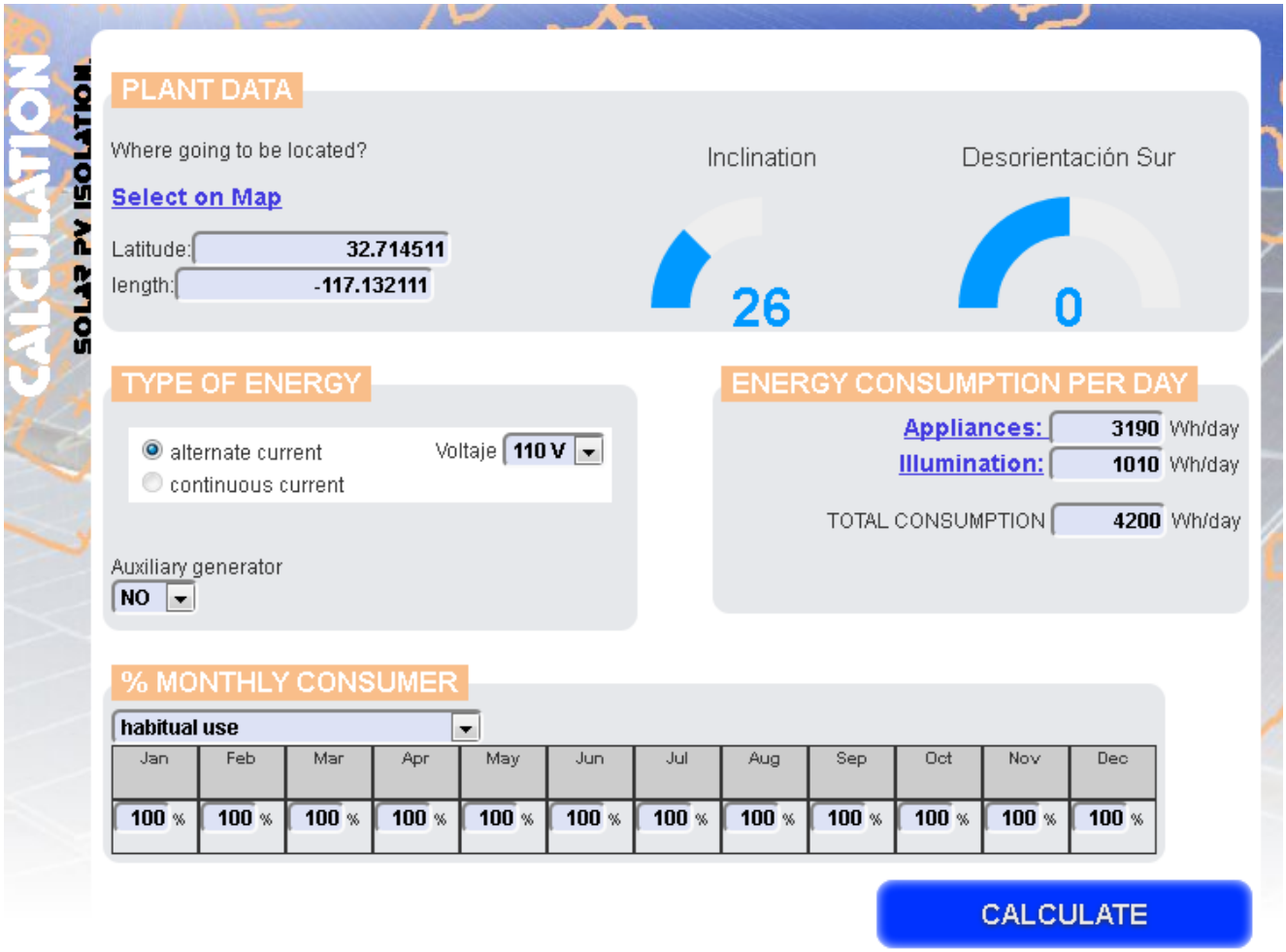
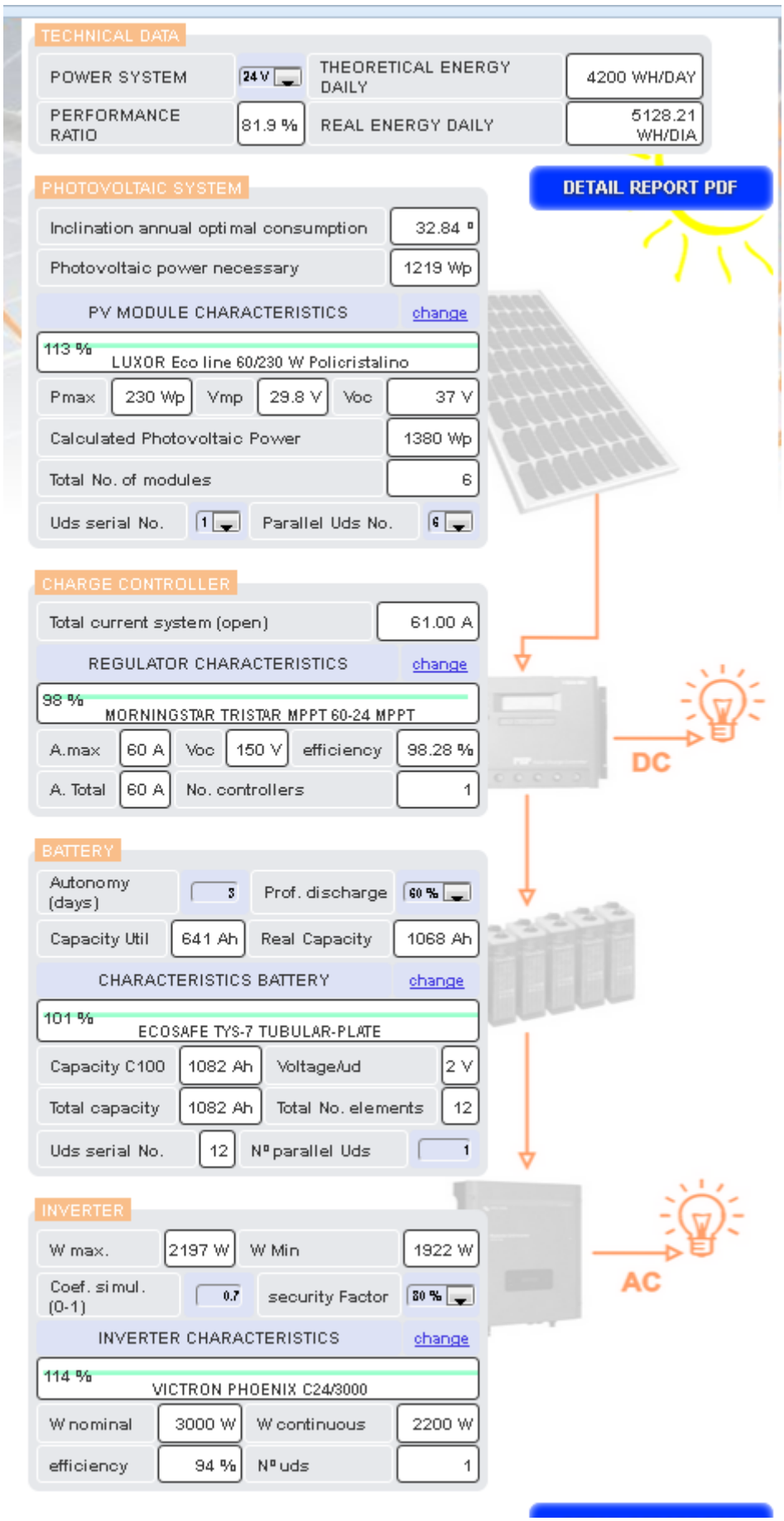
EXAMPLE 4: CALCULATION OF SOLAR PHOTOVOLTAIC INSTALLATION SAN DIEGO (EEUU)

For this example we will calculate an installation on San Diego, EEUU. For an estimated consumption of 4200 Wh / day. For regular use throughout the year. With a system voltage of 24 Vdc, and an output voltage of 110 Vac.

The data input to the program are as follows:



After a preliminary calculation shows us the following results



As the data cover our needs do not change anything and proceed to print the report:

Calculation photovoltaic installation

It makes a report of a solar photovoltaic off-grid from the input data introduced considering the estimated consumption according to the needs and use of the same and solar radiation according to the location, orientation and inclination of the installation.

DETAILS OF LOCATION AND ORIENTATION

The installation is located:3783 Teak Street, San Diego, California 92113, EEUU
The coordinates:32.700644, -117.112885
The PV array will be ready with the following features:
- inclination:26 º
- Disorientation regarding the South: 0 º

Used a system AC current with a voltage of 110 V
The system does not have auxiliary generator

CONSUMPTION.

Consumption is calculated from the use of appliances and lighting per day. The following table shows the existing elements and their consumption:

Consumption by Lighting (day)				
Type	**Nº**	**Hours**	**Energy**	**Total**
fluorescent lamp	2	5	11 W	110 Wh
bulb	2	5	60 W	600 Wh
fluorescent tube	2	5	30 W	300 Wh
			TOTAL	**1010 Wh/d**

Consumer appliances (day)				
appliance	**Hours**	**Energy**	**F.Consumpt.**	**Total**
Television	3	70 W	100 %	21000 Wh
Refrigerator	24	195 W	50 %	234000 Wh
Microwave oven	0.8	800 W	100 %	64000 Wh
			TOTAL	**319000 Wh/d**

THEORETICAL TOTAL DAILY ENERGY 320010 WH/DAY

For the calculation of yield (Performance Ratio) have used the following parameters:

Coefficient battery losses	**5 %**
Battery self discharge coefficient	**0.5 %**
Battery discharge depth	**60 %**
Loss coefficient DC / AC conversion	**6 %**
Loss coefficient wiring	**5 %**
Autonomy System	**3 d**
Performance Ratio	**81.9 %**

What gives us the following results of energy.

TOTAL DAILY ENERGY REAL (WH/DAY): 5128.21

Is a (housing Typical use the following months consumption distributed along the year.

	Ene	Feb	Mar	Abl	May	Jun	Jul	Ago	Sep	Oct	Nov	Dic
% month	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %
consumption (W)	**5128**	**5128**	**5128**	**5128**	**5128**	**5128**	**5128**	**5128**	**5128**	**5128**	**5128**	**5128**

PICO SUN HOURS

For the calculation of the time are pico, we used the NREL-NASA database, contemplating chosen inclination and orientation and location data instead.

The solar declination is calculated with the following formula:

$$[1]\ \delta = 23{,}45 \cdot \operatorname{sen}\left(360 \cdot \frac{284 + \delta_n}{365}\right)$$

δ: declination (degrees)
δ_n: day of year (1 ... 365, taken 1 for the day January)

They have chosen a day of each month, which coincides with a day in mid-month.

For the calculation of the solar elevation values ??are taken:

- $(90° - \varphi - \delta)$ on winter solstice
- $(90° - \varphi + \delta)$ on the summer solstice

φ being the latitude and declination δ.

To determine the optimal inclination have used the following assumptions:

- $\beta = \varphi - \delta$ on the summer solstice
- $\beta = \varphi + \delta$ on winter solstice

through the value $\beta = \varphi$ at the equinoxes
φ being the latitude and declination δ.

To rad_glo_op parameter estimation, we have used the following formula:

$$G_a(\beta_{opt}) = \frac{G_a(0)}{1 - 4{,}46 \cdot 10^{-4} \cdot \beta_{opt} - 1{,}19 \cdot 10^{-4} \cdot \beta_{opt}^2}$$

Ga(βopt): annual mean global irradiation optimally inclined surface (kW · h / m²)
Ga(0º): annual average global horizontal irradiation (kW · h / m²)
βopt:Optimum surface inclination (°)

For obtaining irradiance factor (FI) have been used the following expressions:

$$FI = 1 - [1{,}2 \times 10^{-4}(\beta - \beta_{opt})^2 + 3{,}5 \times 10^{-5}\alpha^2] \quad \text{for } 15° < \beta < 90°$$

$$FI = 1 - [1{,}2 \times 10^{-4}(\beta - \beta_{opt})^2] \quad \text{for } \beta \le 15°$$

FI:Radiation factor (unitless)
β: Actual surface inclination (°)
βopt: Optimum surface inclination (°)
α: surface azimuth (º)

Finally the peak sun hours (HSP) is the result of multiplying the optimal global radiation (Ga (ßopt)) by a factor of irradiation (FI).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Days of month	31	28	31	30	31	30	31	31	30	31	30	31
Declination	-21.27º	-13.62º	-2.02º	9.78º	19.26º	23.39º	21.18º	13.12º	1.81º	-10.33º	-19.6º	-23.4º
Nº day/year	15	45	76	106	137	168	198	229	259	290	321	351
Solar elevation	36.03º	43.68º	55.28º	67.08º	76.56º	80.69º	78.48º	70.42º	59.11º	46.97º	37.7º	33.9º
optimal inclination	53.97º	46.32º	34.72º	22.92º	13.44º	9.31º	11.52º	19.58º	30.89º	43.03º	52.3º	56.1º
rad_glo_hor	3.11	3.88	5.18	6.47	7.03	7.33	7.2	6.54	5.62	4.41	3.46	2.89
rad_glo_op	4.94	5.36	6.16	6.98	7.23	7.44	7.35	6.92	6.44	5.8	5.31	4.81
FI	0.91	0.95	0.99	1	0.98	0.97	0.97	1	1	0.97	0.92	0.89
HSP/day	4.5	5.09	6.1	6.98	7.08	7.21	7.13	6.92	6.44	5.63	4.89	4.28
HSP/month	139.5	142.52	189.1	209.4	219.48	216.3	221.03	214.52	193.2	174.53	146.7	132.68
Temp day max	15.41º	17.11º	20.58º	23.88º	27.98º	31.36º	34.1º	34.01º	31.01º	25.83º	19.11º	14.95º
Consu/HSP day	1139.6	1007.51	840.69	734.7	724.32	711.26	719.24	741.07	796.31	910.87	1048.71	1198.18

CALCULATIONS OF MODULES

To calculate the PV field is taken into account the inclination and orientation chosen, the HSP, the utilization ratio of the charge controller and daytime mean monthly temperatures chosen location. Providing the following values:

* The most unfavorable month as consumption: Diciembre
* Annual optimal inclination: 26.26º
* Inclination annual optimal consumption: 32.84º
* inclination chosen: 26º
* Azimuth modules: 0º
* Monthly average maximum daily temperature (3 months): 16.49º
* Pico Sun Hours worst in months: 4.28 HSP
* Daily from Real Energy modules: 5128.21 Wh/d
* Utilization ratio controller: 1
* Calculated Pico Power modules: 1219 Wp

The election of the module, takes into account the different electrical parameters that determine performance, the units required and their coupling with the regulator and battery.Then are observed details of the module and the load selected.

LUXOR Eco line 60/230 W Policristalino			
Open circuit voltage (Voc):	37 V	Voltage at maximum power (vmp):	29.8 V
Short circuit current (isc):	8.22 A	Current at Maximum Power (Imp):	7.73 A
Maximum power:	230 W	Temperature Coefficient of Pmax:	-0.45 %/ºC
Real power max Average temperature:	233.8295 Wp	Serial Number of modules:	1
Total Pico Power modules:	1380 Wp	No. parallel series:	6
Optimization installation / needs most unfavorable month:	1.13	Total modules:	6
The degree of optimization election equipment / real needs is			113 %

CALCULATIONS REGULATORS

For the choice of the controller takes into account the voltage of the system, the parameters of photovoltaic modules, which gives us a certain degree of optimization. View following:

* Power system: 24 V
* Open circuit voltage modules: 37 V
* Maximum voltage power modules: 29.8 V
* Short circuit current module:8.22 A
* Current at maximum power module: 7.73 A
* No. of series modules installed: 1
* Number of parallel modules installed: 6
* Total modules installed:6
* Intensity module to system voltage (open): 10.14 A
* Current to voltage module system (closed): 7.68 A
* Total current system (open):61 A
* Total current system (closed)): 46.07 A

The choice of the regulator is as follows:

MORNINGSTAR TRISTAR MPPT 60-24 MPPT			
Tension:	24 V	Voltage:	150 V
Rated power:	1600 Wp	Consumption:	56 mA
Capacity:	60 A	Utilization ratio:	0.98
The degree of optimization election equipment / real needs is	98 %	Number of Regulators:	1

CALCULATIONS BATTERIES

For the calculation of the battery, is taken into account, the energy, the system voltage and the depth of discharge and autonomy of the system in days.

* Battery nominal voltage: 24 V
* Depth of discharge of batteries: 60 %
* Autonomy System: 3day
* Real Energy Daily: 5128 Wh/día
* Battery Capacity calculated helpful: 641 Ah
* Actual capacity batteries calculated: 1068 Ah

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ECOSAFE TYS-7 TUBULAR-PLATE									
Capacities according to their hours of download:									
C 10:	786 Ah	C 20:	887 Ah	C 40:	1049 Ah	C 100:	1082 Ah	C 120:	1095 Ah

Tension	2 V	Serial No. elements:	12
Nominal capacity accumulator:	1082 Ah	No. parallel series:	1
Battery Nominal voltage:	24 V	Total elements:	12
The degree of optimization election equipment / real needs is			101 %

INVERTER

For the sizing of the inverter is used the following data:

* Voltage DC system: 24 V
* AC output voltage: 110 V
* Maximum power: 2197 W
* Coefficient Concurrency: 0.7
* Power requirement: 1538 W
* Safety factor: 0.8
* Power calculation: 1922 W

The choice of inverter is as follows:

VICTRON PHOENIX C24/3000			
Tension:	24 V	Rated power:	3000 W
Continuous power:	2200 W	Pico Power:	6000 W
Consumption empty:	15 W	Efficiency:	94 %
Utilization ratio:	87 %	Number of inverters:	1
The degree of optimization election equipment / real needs is			114 %

SUMMARY

Summary of the elements resulting from the calculation

Units	Elements
6	Module type - LUXOR Eco line 60/230 W Policristalino
1	Regulator type - MORNINGSTAR TRISTAR MPPT 60-24 MPPT
12	Battery type - ECOSAFE TYS-7 TUBULAR-PLATE
1	Inverter type - VICTRON PHOENIX C24/3000

Consumptions with selected elements and components of the installation calculated comparative obtain the following estimated consumption and production over the year

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Consumption	159	144	159	154	159	154	159	159	154	159	154	159
Production	189	193	256	284	298	293	300	291	262	237	199	180

Total consumption per year: 1873 Kw

Total production per year: 2982 Kw

Total kg / year CO2 avoided: 1616