Specifier's Guide for DC Controllers

Baseline's DC irrigation controller is a solar powered controller that operates without the need for a new power feed.

The basic power source for a DC controller is a deep-cycle battery that is charged with a solar panel. The number of solar panels and batteries you will need to power your system depends on a number of factors including the following:

- The Baseline controller you are using
- The type and number of communication modules
- The quantity of two-wire devices on the system
- The average solar irradiance for your location during the months when the DC controller is powered

Baseline has a Solar Calculator Worksheet that helps you determine how many solar panels and batteries you need to power your system. However, before you use the worksheet, please review this document to make sure you have the proper information for your decision making process.

Note: This specifier's guide is intended for customers who need to set up a new solar system at their site. If you have an existing DC power feed at your site, you do not need to use this document.

Preliminary Considerations

When you are designing an irrigation system with a solar-powered controller, you need to consider whether the controller will be powered all year long. Obviously, the controller is powered during the months when it is watering, but even when the Baseline controller is set to OFF for seasonal shutdown, it still draws power for communication and device readings. As a matter of fact, the amount of power required to open/close valves during an actual watering cycle is only slightly higher than the amount used when the controller is in an idle state.

In many locations, the requirements for a system that will be powered all year long are quite different from a system that is powered only during the summer watering months. For example, in northern latitudes, the angle and position of the sun are significantly different during the summer and winter months. In order to generate the proper amount of power during the winter, you may need to adjust the position and tilt of your solar panel or you may need additional panels. Also, if your battery is stored in an unheated enclosure, you will need to compensate for decreased battery capacity during cold weather.

Bear in mind, a DC controller system is not a "set and forget" system. You need to check the fluid level in the battery on a regular schedule. You may also need to change the orientation and tilt of your solar panel over the course of a year. However, if you prefer to spend less time adjusting the system, you may need to increase the number of solar panels and batteries to provide enough power for your system.

Understanding Solar Irradiance

Wikipedia defines **solar irradiance** (also known as solar insolation) as "the power per unit area received from the Sun in the form of electromagnetic radiation in the wavelength range of the measuring instrument. The solar irradiance integrated over time is called solar irradiation, insolation, or solar exposure. However, insolation is often used interchangeably with irradiance in practice."[1]

Solar irradiance is usually expressed in watts per square meter (W/m^2), but is also expressed on a daily basis as watts per square meter per day (W/m^2/day).

Factors that Affect Solar Irradiance Values

- **Cloudiness**: The amount of solar irradiance decreases when cloud cover increases.
- **Location**: Location determines climate, which, in turn, influences the amount of cloud cover. Latitude also determines the angle of incoming solar radiation.
- **Season**: The season determines the angle of the sun and the hours of sunlight/day. For example, the Northern Hemisphere is tilted toward the sun during part of the year and away from the sun during another part of the year.
- **Solar panel surface tilt**: The angle of the solar panel affects its exposure to direct rays of the sun for a period of time. The panel collects solar radiation most effectively when the sun's rays shine straight down onto the panel's surface.
- **Solar panel surface orientation**: Orienting the solar panel in a direction that maximizes its exposure to direct sunlight will optimize the collection efficiency. The solar panel should always face toward the equator. In the Northern Hemisphere, the panel should face south. Note that magnetic south and true south are not the same. Use a compass that has the declination corrected or GPS to find true south.
- **Site factors**: Trees, large buildings, or other structures or obstructions surrounding the site might cast shadows onto a tilted solar panel at various times of day or during winter months when the sun is at a low angle in the sky.

How to Find Solar Irradiance Values

You need to know the average solar irradiance value for the site where the DC controller will be located in order to determine how much solar power is available and how many solar panels and batteries are required to operate the DC controller and its devices.

NASA provides an interactive, online database where you can generate a report showing the average solar irradiance values for your site. The database uses 22 Year Solar Climatological Averages (Jul 1983 - Jun 2005) and 30 Year Meteorology Climatological Averages (Jan 1984 - Dec 2013).

Refer to **Finding Solar Irradiance Values in the NASA Database** on page 7 of this document for the instructions.

[1] Wikipedia contributors, "Solar irradiance," Wikipedia, The Free Encyclopedia, https://en.wikipedia.org/w/index.php?title=Solar_irradiance&oldid=857857713 (accessed September 18, 2018).

Understanding Units of Energy and Power

When you are specifying a DC controller system, you will come across many different units of measurement for energy and power. In order to keep all this straight, here's a brief refresher on the difference between energy and power:

- **Energy** is the force that causes a change. Energy can transfer from one object to another and can be transformed from one form to another. The following units are measurements of energy:
  - **Watt Hour (Wh)**
  - **Kilowatt Hour (kWh)**
  - **Ampere Hour (AHr)** Also known as "amp hour"
- **Power** is a measurement of the rate of energy transfer. You can also think of it as the rate at which energy is generated or used. The most commonly used unit of measurement for power is the watt or kilowatt.
  - **Watt (W)**: A measure of electrical power or amount of work done in a unit of time and equal to the rate of current flow (amps) multiplied by the voltage of that flow (volts). One amp of current flowing at a potential of one volt produces one watt of power.
  - **Kilowatt (kW)**: 1,000 watts

Here are some additional electrical units that you will see mentioned when working with solar power:

- **Voltage (V)**: A measure of the force or "push" given the electrons in an electrical circuit; a measure of electrical potential. One volt produces one amp of current when acting against a resistance of one ohm.
- **Current:** A measure of the flow of electrons past a point.
  - **Ampere**: Also known as "amp." The base unit of electric current in the International System of Units (SI).

Understanding Battery Capacity

A true deep-cycle battery (or batteries) is a key component of your DC controller system. The battery stores the energy from the solar panels and delivers power to the irrigation controller on a continual basis.

Battery storage capacity is measured in Ampere hours (AHr).

Type of Battery: 12V true deep-cycle flooded battery (if stored inside the controller pedestal, use Group 24 or Group 27). AGM (glassmat) batteries are not compatible with the factory-configured settings on the charge controller.

Depth of Discharge: A deep-cycle battery is designed to be cycled (discharged and recharged) repeatedly. However, the depth of discharge is an important factor in battery life.

Depth of discharge (DOD) measures how deeply a battery is discharged. When a battery is fully charged, the DOD is 0%. When 30% of a battery's capacity has been used and 70% remains unused, the DOD is 30%.

Battery manufacturers recommend limiting the depth of discharge to about 20% and suggest that you should never go below 50%.

You can calculate the DOD with the following formula:

Amps used*(minutes/60)/AmpereHours of battery = percent discharge

Example: A 100AHr battery is discharged for 20 minutes at 50A, the depth of discharge is:

50*(20/60)/100 = 16.7%

Discharge Cycles: A battery cycle refers to a complete discharge and recharge. Batteries are rated for a given number of discharge cycles, at standard depth of discharge percentages. Battery life is also affected by how deeply the battery is cycled each time. The deeper the depth of discharge, the shorter the battery lifespan will be.

Battery Maintenance: Baseline recommends flooded lead acid batteries for use with our DC controller systems. These batteries have removable vents and you must check the acid level and add distilled water on a regular schedule in order to extend the life of the battery. Monitor the fluid levels in the battery frequently to determine how often your batteries need watering.

Battery Temperature: As the temperature decreases, the capacity of a battery also decreases. Battery charging voltage also changes with temperature. Battery life is shortened by exposure to high temperatures.

Battery charging is affected by temperature. The SunSaver charge controller included in the DC irrigation controller system has a temperature sensor that helps ensure the battery is properly charged regardless of the temperature. Because the SunSaver is installed inside the irrigation controller enclosure, it is important to locate the battery nearby where the ambient temperature is similar.

If your batteries are stored in an outdoor location and you plan to have your DC controller powered through seasons of varying temperatures, this will have an impact on your battery capacity and battery life.

Age of Battery: As batteries age and have gone through many discharge cycles, they accept less of a recharge over time which results in shorter run time.

Number of Batteries: When specifying a DC controller system, it's best to start with the correct number of batteries. If you discover that your battery capacity is too low after your system has been in operation for some time, it is never a good practice to combine a new battery with an old battery. When batteries are interconnected, they are treated as a single resource, and the limiting factor is the oldest and weakest battery.

Interconnected batteries should be identical – the same age, the same construction, and the same rating.

If multiple batteries are required, they must be wired in parallel.

Autonomous Days: Also known as "days of autonomy." The number of days a battery bank can power the loads you have connected to the system without being recharged by the solar panels. A standard number for this field is 3 to 5, but you can run a report in the NASA Power site based on 22 year climatological averages for your area.

Refer to **Finding Autonomous Day Values in the NASA Database** on page 8 of this document for the instructions.

Other DC Controller System Components

Charge Controller: A component of a solar system that regulates the flow of current to and from the battery to protect the battery from overcharge, over discharge, or other control functions. The charge controller may also monitor system operational status. For more information about the charge controller included with the Baseline DC Controller, see the DC Controller Technical Specification.

Solar Panel: The solar panels (also known as photovoltaic modules) make electricity from sunlight. Many different types of panels are available with different construction methods, different types of cells, and different power output. Baseline offers a compatible solar panel for our DC controller system. For more information about the solar panel that is available from Baseline, see the DC Controller Technical Specification.

If multiple solar panels are required, they must be wired in parallel.

When you are planning the installation of your DC controller system, you need to consider the distance between your solar panels and the irrigation controller enclosure where the charge controller is located. In order to maintain the voltage drop within acceptable limits (no greater than 3%), and keep your wire affordable, do not exceed the distances shown in the 12 Volt Nominal Wire Chart in the SunSaver Installation and Operation Manual. You may also want to use an online voltage drop calculator to ensure that your planned system is within an acceptable range.

Solar Panel Mount: When you purchase a solar panel from Baseline, we include a Tamarack UNI-SP/01A Universal Side-of-Pole Mount. You must purchase the pole separately.

If the solar panel is to be mounted on a free-standing pole, make sure the pole is installed according to the guidelines in the Side of Pole Mount Foundation Recommendations document found on the Baseline website.

Remember that solar panels are valuable. Depending on the installation location, it may be prudent to consider some form of theft protection.

Using Baseline's Solar Calculator Worksheet

Baseline's Solar Calculator Worksheet is a Microsoft Excel worksheet that is programmed to calculate the number of batteries and solar panels required to operate a DC controller system.

DISCLAIMER: Due to site-specific variables, the Solar Calculator Worksheet can only estimate the number of solar panels and batteries for your project.

1. Download the Solar Calculator Worksheet from the Baseline website.

   https://www.baselinesystems.com/public_documents/Solar_Calculator_Worksheet.xlsx

2. Fill in the fields on the worksheet and find the results in the gold highlighted cells.

   To get the best results from the Solar Calculator Worksheet, you should have the following information about your installation:

   - The model of Baseline irrigation controller
   - The type and number of two-wire devices
   - The lowest solar irradiance value (refer to **Finding Solar Irradiance Values in the NASA Database** on page 7.)
   - The wattage rating of the solar panel
   - The number of days you'll require the system to operate with no solar production (refer to **Finding Autonomous Day Values in the NASA Database** on page 8.)
   - The amp hour rating of the battery
   - The depth of battery discharge
   - The lowest average temperature that the battery will be exposed to

3. Record the Solar Calculator results on the Installer's Reference Sheet on page 10.
4. Give the completed reference sheet to the installer.

Appendix

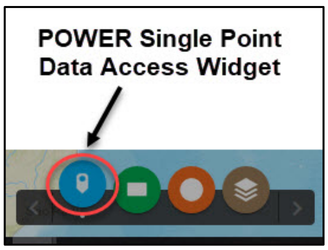
Finding Solar Irradiance Values in the NASA Database

Note: Before you go to the NASA site, you may want to record the latitude (lat) and longitude (long) for the DC controller location in decimal degrees. Example: lat 43.888556, long -116.443838

1. In a Web browser, type the following URL:

   https://power.larc.nasa.gov/

2. Click the **Power Data Access Viewer** button. The Welcome pop-up box displays on the map interface.
3. In the Welcome pop-up box, click the **Access Data** button.
4. Make sure the **POWER Single Point Data Access** application widget is selected at the bottom of the screen. The parameters panel displays on the left side of the page.

5. Click the drop-down arrow in the **User Community** field, and select **Sustainable Buildings** from the list.
6. In the **Temporal Average** field, click **Climatology**.
7. In the **Latitude** and **Longitude** fields, type or paste the coordinates that you recorded earlier or zoom in on the map and add a point to automatically enter the coordinates.
8. No date range is needed, so you do not need to change the fields under **Time Extent**.
9. In the **Output File Formats** field, click the checkboxes for the type of data output that you want. If you select ASCII, the report data displays in a browser tab. Other options generate a downloadable file.
10. In the **Parameters** field, scroll down until you see **Solar Irradiance and Related Parameters**. Click to expand the folder.
11. Click to select the **Solar Irradiance for Equator Facing Tilted Surfaces** parameter.
12. Drag the scroll bar to the bottom of the parameters panel, and then click **Submit**. The results box displays with links to your selected output types.
13. Click the link to open/download the report.

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File Edit Format View Help

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NASA/POWER SRB/FLASHFlux/MERRA2/ 0.5 x 0.5 Degree Climatologies
22-year Additional Solar Parameter Monthly & Annual Climatologies (July 1983 - June 2005), 30-year Meteorological and Solar Monthly & Annual Climatologies (January
1984 - December 2013)
Location: Latitude  43.8886   Longitude -116.4438
Elevation from MERRA-2: Average for 1/2x1/2 degree lat/lon region = 1145.44 meters   Site = na
Climate zone: na (reference Briggs et al: http://www.energycodes.gov)
Value for missing model data cannot be computed or out of model availability range: -999
Parameter(s):
SI_EF_TILTED_SURFACE      SRB/FLASHFlux 1/2x1/2 Solar Irradiance for Equator Facing Tilted Surfaces (Set of Surfaces) (kW-hr/m^2/day)
SI_EF_OPTIMAL             SRB/FLASHFlux 1/2x1/2 Solar Irradiance Optimal (kW-hr/m^2/day)
SI_EF_OPTIMAL_ANG         SRB/FLASHFlux 1/2x1/2 Solar Irradiance Optimal Angle (Degrees)
SI_EF_TILTED_ANG_ORT      SRB/FLASHFlux 1/2x1/2 Solar Irradiance Tilted Surface Orientation (N/S Orientation)
Note(s):
Northward facing tilted surfaces are designated negative (-)
```

PARAMETER	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
-END HEADER-													
SI_EF_TILTED_SURFACE_0	1.72	2.55	4.07	5.38	6.36	7.24	7.39	6.46	5.00	3.42	1.98	1.46	4.42
SI_EF_TILTED_SURFACE_28	2.88	3.66	5.12	5.87	6.36	6.92	7.21	6.85	6.06	4.88	3.15	2.51	5.12
SI_EF_TILTED_SURFACE_43	3.29	3.99	5.29	5.68	5.88	6.27	6.58	6.52	6.14	5.27	3.54	2.89	5.11
SI_EF_TILTED_SURFACE_58	3.52	4.09	5.16	5.22	5.14	5.37	5.70	5.88	5.87	5.35	3.73	3.10	4.84
SI_EF_TILTED_SURFACE_90	3.35	3.58	3.99	3.37	2.88	2.82	3.06	3.57	4.25	4.50	3.40	2.95	3.48
SI_EF_OPTIMAL	3.57	4.09	5.29	5.88	6.51	7.26	7.45	6.88	6.15	5.36	3.74	3.14	5.44
SI_EF_OPTIMAL_ANG	68.00	58.00	44.00	27.00	14.00	6.00	8.00	22.00	39.00	54.00	63.00	68.00	39.00
SI_EF_TILTED_ANG_ORT	S	S	S	S	S	S	S	S	S	S	S	S	S

14. Answer the following questions in order to find the appropriate solar irradiance value:

    - Will you adjust the tilt angle throughout the year to maximize the solar collection?

      Yes – Review the SI_EF_OPTIMAL_ANG row in the table to find the optimal tilt angle for each month. Determine how often and when you plan to make the angle adjustments shown in that row, look in the SI_EF_OPTIMAL row and find the lowest value. Record this value so you can use it in Baseline’s Solar Calculator Worksheet.

      Note: You don’t have to adjust the angle every month, but some adjustments during the year may yield better results.

      No – Determine what your static tilt angle will be. Go to the row in the table that is closest to that angle and find the lowest value. Record this value so you can use it in Baseline’s Solar Calculator Worksheet.

      Note: Record the tilt angle on the Installer’s Reference Sheet on page 10.

    - Will the irrigation controller be powered on all year?

      Yes – Use the value that you recorded above.

      No – In the appropriate row based on your answer to the tilt angle question, review only the columns for the months when the controller will be powered on and find the lowest value. Record this value so you can use it in Baseline’s Solar Calculator Worksheet.

Finding Autonomous Day Values in the NASA Database

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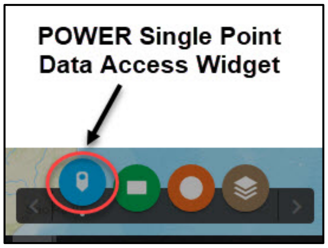

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6. In the **Temporal Average** field, click **Climatology**.
7. In the **Latitude** and **Longitude** fields, type or paste the coordinates that you recorded earlier or zoom in on the map and add a point to automatically enter the coordinates.
8. No date range is needed, so you do not need to change the fields under **Time Extent**.
9. In the **Output File Formats** field, click the checkboxes for the type of data output that you want. If you select ASCII, the report data displays in a browser tab. Other options generate a downloadable file.
10. In the **Parameters** field, scroll down until you see **Sizing Battery or other Energy-Storage Systems**. Click to expand the folder.
11. Click to select the **Equivalent Number of NO-SUN or BLACK Days Over a Consecutive Month Period** parameter.
12. Drag the scroll bar to the bottom of the parameters panel, and then click **Submit**. The results box displays with links to your selected output types.
13. Click the link to open/download the report.
14. Answer the following question in order to calculate the appropriate autonomous days value:

    Will the irrigation controller be powered on all year?

    Yes – Find the highest value. Record this value so you can use it in Baseline's Solar Calculator Worksheet.

    No – Find the highest value for the months when the controller will be powered on. Record this value so you can use it in Baseline's Solar Calculator Worksheet.

Installer's Reference Sheet

Baseline Products

- ☐ BaseStation 3200
- ☐ BaseStation 1000
- ☐ AG 1000
- ☐ SubStation
- ☐ FlowStation

Two-Wire Devices

QTY	Part Number	Description
	BL-5201DC	Single Station biCoder
	BL-5202DC	Two Station biCoder
	BL-5201PR	Pump Start Relay biCoder
	BL-5303	Air Temperature Sensor
	BL-5308 or BL-5309	Flow biCoder
	BL-PFS Series Flow Sensor	PVC Flow Sensor
	BL-5315 or BL-5311	biSensor Soil Moisture Sensor
	BL-5401	Coach's Button
	BL-5402	Event biCoder

Batteries

Number of batteries to be installed:___________

Brand and description of the battery being specified:_______________________________________

Type of battery enclosure, if required:____

Solar Panels

Number of solar panels to be installed:________

Solar panel direction: _______________________

Solar Panel Tilt Angle

One angle for the entire year:________________

Change the angle as indicated for the selected months:

☐ January	______________	☐ July	______________
☐ February	______________	☐ August	______________
☐ March	______________	☐ September	______________
☐ April	______________	☐ October	______________
☐ May	______________	☐ November	______________
☐ June	______________	☐ December	______________