dcbel™ Solar Guide

1 What is the purpose of this guide?

This Solar Guide will help you determine if the dcbel™ r16 is compatible with your client's solar installation plans. In this guide, you will find:

- dcbel's key functionalities
- An FAQ about dcbel™ and Photovoltaic (PV) systems
- Solar sizing methodology with key examples for California homes
- Rapid shutdown regulations and compatibility specifications

If you are a solar installer or have experience with PV systems, you can go directly to Section 5 for advanced technical information.

If you want to know more about PV systems and general installation information continue reading below.

2 Disclaimer

The information contained in this document is intended to be used as a reference and remains subject to change without notice. dcbel™ does not endorse any of the brands or companies mentioned in this document, they are used as a reference. All brands and related trademarks mentioned in this document belong to their respective companies.

All references and calculations in this document are intended for reference purposes. This is not intended to be a technical manual for installation or modification of equipment. Any installation or modification of a home's electricity system must be compliant with all national and local electrical codes and regulations. dcbel™ will not be held responsible if regulations have changed since the publication of this document. It is the installers' or homeowner's responsibility to reference the latest version of their local electrical codes.

3 What are dcbel™'s key functionalities?

The dcbel r16 replaces the functions normally provided by the following equipment:

- a level 2 electric vehicle charger
- a fast DC bidirectional electric vehicle charger
- solar inverter
- a stationary battery charger / inverter

For more details on dcbel™'s specifications, view the dcbel datasheet.

4 Frequently Asked Questions about Compatibility

4.1 Installing Solar Panel Arrays with dcbel™

4.1.1 What is required for a solar installation?

A dcbel™ r16 can function as a solar inverter for a standard residential solar installation. Please note that your project will require additional hardware, cables and permits. To learn more, you can consult:

- Non-profit associations like SEIA
- Government websites like GoSolarCalifornia
- Specialized websites like EnergySage
- Qualified solar installers

4.1.2 Do I need a permit to install dcbel ™ at my home?

The dcbel™ installation will be one part of your solar project which may require a permit. In general, article 690 of the National Fire Protection Agency (NFPA) and National Electric Code (NEC) 70 provides all the requirements for a safe solar installation.

In addition to the NFPA requirements, each state, utility, county and municipality have their own set of regulations and requirements. A qualified solar installer is responsible for ensuring that all the permits and licenses are obtained for your installation.

4.1.3 Can dcbel™ work with my existing residential solar panels?

If you already have a solar inverter installed, the dcbel system can operate in parallel. If the solar panel array is connected to a separate inverter, you will not be able to take advantage of the optimization and energy management benefits of dcbel.

If a solar panel array is already installed on a roof, its compatibility with dcbel is not guaranteed. In order to determine if an existing solar panel array is compatible with dcbel™, refer to section 7 of this document and use your solar panel specifications and location temperature data to perform the sizing calculations.

If the number of panels in your installation falls within our specifications for power, open circuit voltage and short circuit current, then your installation is compatible with dcbel.

4.1.4 Is dcbel™ compatible with micro-inverters?

dcbel™'s PV inverter inputs are in DC and cannot accept AC from micro-inverters. The PV must be connected to dcbel in DC.

4.1.5 Is dcbel™ compatible with my existing solar inverter?

No, dcbel™ has its own solar inverter.

4.1.6 Is dcbel™ compatible with all types of PV modules (type, number of cells…)?

dcbel™ is compatible with all types of PV modules. A solar panel array must be sized to dcbel's solar inverter specifications.

4.1.7 What is dcbel 's compatibility with rapid shutdown?

dcbel is compatible with all rapid shutdown devices that are compliant with NFPA 70 2020 article 690.12. All rapid shutdown devices are designed to be universally compatible with any inverter. Additionally, dcbel™ offer its own PV Rapid Shutdown (PVRSS) and DC Optimizer devices.

4.1.8 Is dcbel™ compatible with PV DC optimizers?

dcbel™ does not require the use of PV DC optimizers. The unit's two separate MPPT inputs provide the flexibility to optimize your solar output based on your roof's surface area. Depending on the unique characteristics of your home, installing DC optimizers may allow you to harvest additional energy from your solar installation. The additional benefit of optimizers varies from home to home and should only be installed after a qualified professional has performed a site assessment.

Note: DC optimizers are not designed to be universally compatible with all inverters.

4.1.9 How many Maximum Power Point Tracker (MPPT) inputs does dcbel™ support?

dcbel™ is equipped with two MPPT inputs. You can install two independent solar panel arrays for more flexibility. Having two separate inputs allows you to take advantage of your roof's surface area which can result in improved power generation and savings.

4.1.10 Is dcbel ™ compatible with a solar installation that is partially shaded or installed on a sloped rooftop?

Yes, dcbel's two MPPT inputs means that you can have one separate MPPT array in the section of your roof that is shaded or facing east and a second array in the non-shaded or west-facing section. This would allow you to benefit from the energy of both the morning and afternoon sun.

Since each of these arrays experiences different patterns of solar irradiance throughout the day, they are managed differently by dcbel's MPPT algorithm in order to obtain the most power out of each array.

See questions 4.1.8 and 4.1.9 for more details.

4.1.11 Is dcbel™ compatible with net metering?

dcbel™ is capable of net metering if there is a program in place by your local utility. See your local utility rules and regulations for more details.

4.2 Sizing Solar Panel Arrays with dcbel™

4.2.1 How many solar panels will my home need?

This depends on your home's electric consumption (load) and what percentage of this load you wish to be powered by solar. A qualified solar panel installer will help you determine the best solar panel sizing for your needs. Additionally, the solar panel array size may be limited by the size of your roof, your location, the characteristics of the solar inverter and the brand and model of the solar panel.

For more details, please consult Section 5 (Solar sizing data for selected location in California).

4.2.2 Is there a maximum limit of solar power that dcbel™ can handle?

dcbel™ can manage up to 20 kW of installed PV power or 10 kW per MPPT.

The actual number of panels that can be installed depends on the characteristics of the panels like open circuit voltage, short circuit current and temperature derating factors which depend on the panel brand and model.

The extreme minimum temperature of the location will also affect the maximum number of panels that can be installed.

See Section 7 at the end of this document for more details about determining the maximum number of panels that can be installed to function with a dcbel unit.

4.2.3 How are solar panel systems sized?

Each Solar panel array (solar panel system) is sized in accordance with the solar inverter specifications, solar panel specifications and location of the installation.

For more details, please consult Section 5 (Solar sizing data for selected locations in California).

4.2.4 Why does my PV sizing not match the dcbel™ maximum input capacity?

As explained in section 4.2.1, the number of solar panels and the maximum amount of solar power depend on your energy needs, your location, the inverter type and solar panel specifications.

Your solar power needs may be below the inverter's maximum capacity.

On the other hand, your needs may be higher than the inverter's maximum input capacity, limiting the size of the solar array that can be installed.

4.3 Working off-grid with dcbel™

4.3.1 Can dcbel™ operate completely off-grid?

dcbel™ is designed to operate on-grid with blackout power capabilities. It is not recommended to use dcbel™ in a completely off-grid system.

4.3.2 What do I need to install to be able to operate in blackout power mode?

A dcbel™ unit and Blackout Power kit includes all the major hardware components that enable blackout power mode.

4.4 General Questions about dcbel™

4.4.1 What is dcbel™ 's warranty?

Please refer to the dcbel warranty document.

4.4.2 I'm a solar installer – Can I offer dcbel™ to my clients?

dcbel™ is always interested in partnering with qualified solar installers.

For further information on becoming a dcbel™ partner, please complete the Partner Form on the dcbel™ website.

5 Solar sizing data for selected locations in California

5.1 Introduction

This section presents typical configurations of solar panel arrays using dcbel. Three locations in California using two different modes of solar panels are used for these examples.

Results and selected configurations are presented for each location followed by a brief qualitative analysis and high-level schematics.

5.2 Methodology and Data

This section presents a high-level view of the methodology and data for calculating the solar panel array sizing presented in Section 5.3 below.

Two dcbel™ configurations were selected for the sizing examples:

- dcbel™ with one MPPT (10 000 Watts peak DC input);
- dcbel™ with two MPPTs (20 000 Watts peak DC input).

Three locations were selected for the sizing examples:

- San Diego area;
- Los Angeles area;
- San Francisco area.

Two solar panel models were selected for the sizing examples:

- Sun Power SPR-X22-360 (360 Watts);
- Canadian Solar CS6X-300P (300 Watts).

Five typical solar panel power configurations were selected for the sizing examples:

- 2,500 Watts;
- 5,000 Watts;
- 7,500 Watts;
- 10,000 Watts;
- 15,000 Watts.

Derating for temperature was performed using the voltage correction factors table 690.7(A) from the NFPA 70 2020, article 690.7.

For a detailed description of the methodology with formulas and examples, please refer to section 7.

5.3 Results and Discussion

Results are presented for the San Diego, Los Angeles, and San Francisco areas.

5.3.1 San Diego Area Results

The table below presents the solar panel sizing results for various desired solar panel output configurations using dcbel with the Sun Power SPR-X22-360 panels.

PV Desired Output (W)	PV Max DC Input (Wp)	Number of MPPT	Total Number of panels	Number of Strings	Number of panels per string
2 500	2 520	1	7	1	7
5 000	5 040	1	14	2	7
7 500	7 560	1	21	3	7
10 000	12 600	2	35	5	7
15 000	15 120	2	42	6	7

The table below presents the solar panel sizing results for various desired solar panel output configurations using dcbel™ with the Canadian Solar CS6X-300P panel:

PV Desired Output (W)	PV Max DC Input (Wp)	Number of MPPT	Total Number of panels	Number of Strings	Number of panels per string
2 500	3 600	1	12	1	12
5 000	6 600	1	22	2	11
7 500	7200	1	24	2	12
10 000	13 200	2	44	4	11
15 000	14 400	2	48	4	12

5.3.2 Los Angeles Area

The table below presents the solar panel sizing results for various desired solar panel output configurations using dcbel with the Sun Power SPR-X22-360 panels:

PV Desired Output (W)	PV Max DC Input (Wp)	Number of MPPT	Total Number of panels	Number of Strings	Number of panels per string
2 500	2 520	1	7	1	7
5 000	5 040	1	14	2	7
7 500	7 560	1	21	3	7
10 000	12 600	2	35	5	7
15 000	15 120	2	42	6	7

The table below presents the solar panel sizing results for various desired solar panel output configurations using dcbel™ with the Canadian Solar CS6X-300P panels:

PV Desired Output (W)	PV Max DC Input (Wp)	Number of MPPT	Total Number of panels	Number of Strings	Number of panels per string
2 500	3 600	1	12	1	12
5 000	6 600	1	22	2	11
7 500	7200	1	24	2	12
10 000	13 200	2	44	4	11
15 000	14 400	2	48	4	12

5.3.3 San Francisco Area

The table below presents the solar panel sizing results for various desired solar panel output configurations using dcbel with the Sun Power SPR-X22-360 panels:

PV Desired Output (W)	PV Max DC Input (Wp)	Number of MPPT	Total Number of panels	Number of Strings	Number of panels per string
2 500	2 520	1	7	1	7
5 000	5 040	1	14	2	7
7 500	7 560	1	21	3	7
10 000	12 600	2	35	5	7
15 000	15 120	2	42	6	7

The table below presents the solar panel sizing results for various desired solar panel output configurations using dcbel with the Canadian Solar CS6X-300P panels:

PV Desired Output (W)	PV Max DC Input (Wp)	Number of MPPT	Total Number of panels	Number of Strings	Number of panels per string
2 500	3 600	1	12	1	12
5 000	6 600	1	22	2	11
7 500	7200	1	24	2	12
10 000	13 200	2	44	4	11
15 000	14 400	2	48	4	12

5.3.4 Discussion of Results

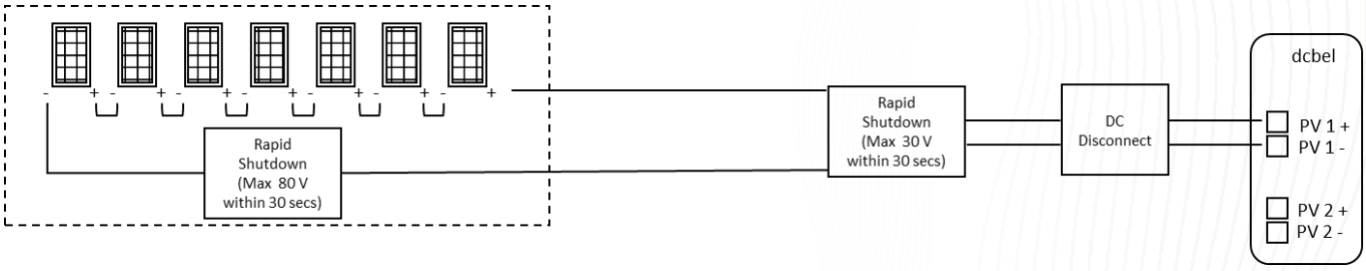
As seen in the tables above, when considering the maximum number of panels, the configurations are the same for the respective brands regardless of the location in California. This is expected, as the maximum number of panels in a string is determined by the open circuit voltage corrected for extreme minimum temperature. The temperature is similar in the locations used for this example.

5.4 Schematics for Typical Solar Panel Configurations

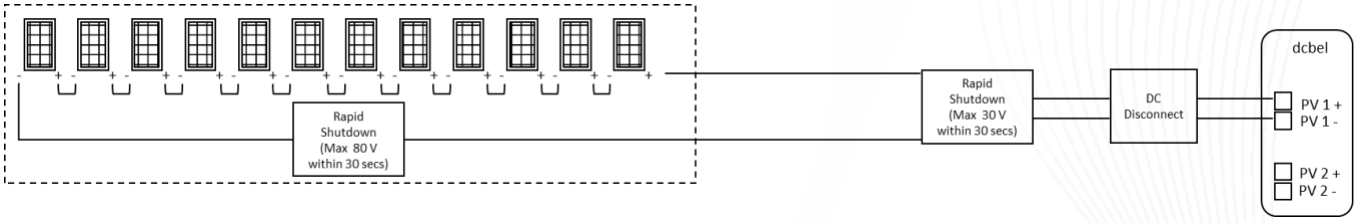
This section presents high level schematics of the 2,500 W, 5,000 W, 7,500 W, 10,000 W and 15,000 W configurations for the Sun Power SPR-X22-360 and the Canadian Solar CS6X-300P solar panels.

5.4.1 2, 500 Watts configurations schematics

Sun Power SPR-X22-360: 2,500 W with 7 panels (1 string of 7 panels in series)

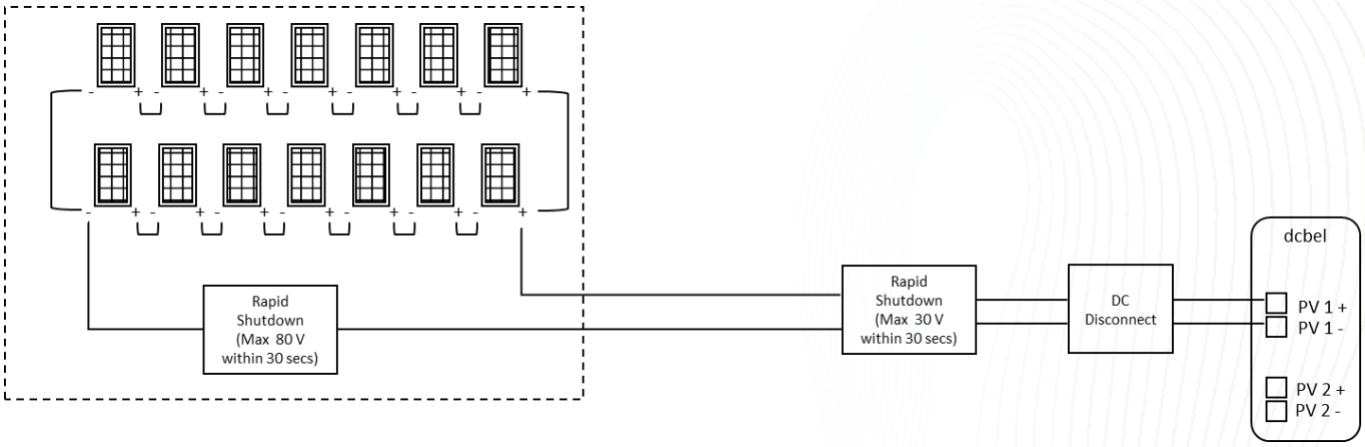


Canadian Solar CS6X-300P: 2,500 W with 12 panels (1 string of 12 panels in series)

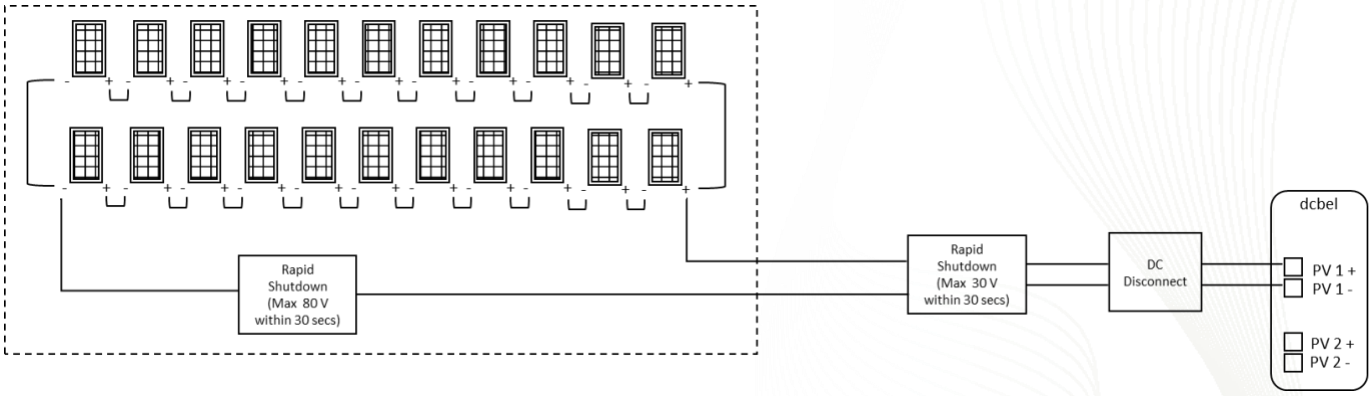


5.4.2 5,000 Watts configurations schematics

Sun Power SPR-X22-360: 5,000 W with 14 panels (2 string of 7 panels in series)

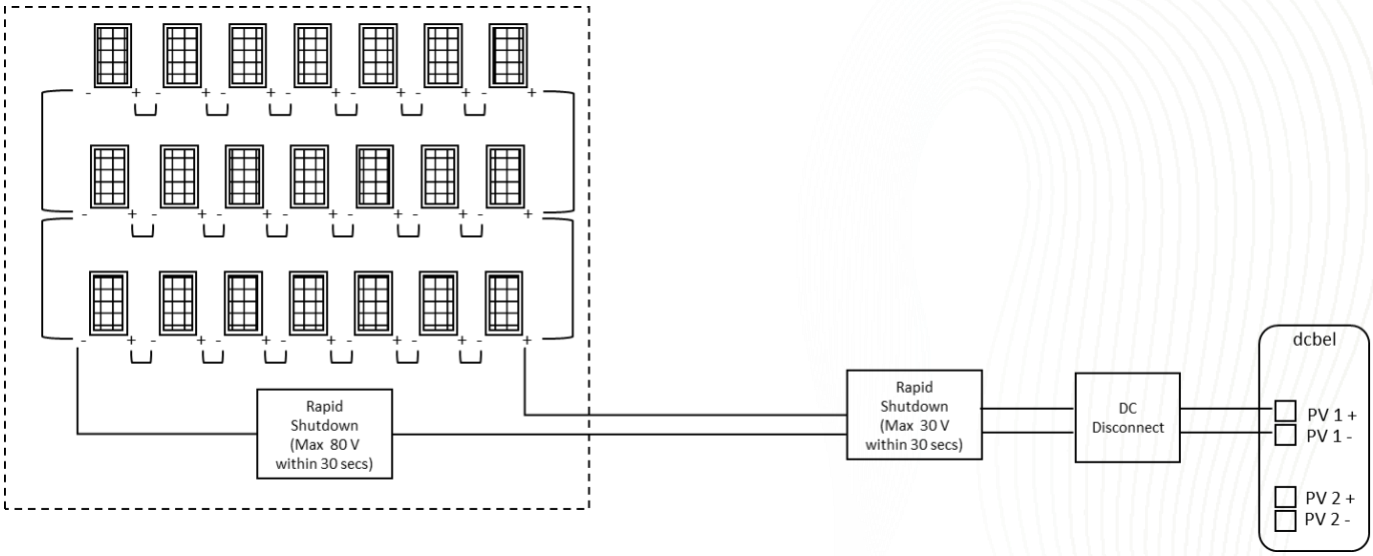


Canadian Solar CS6X-300P: 5,000 W with 22 panels (2 string of 11 panels in series)

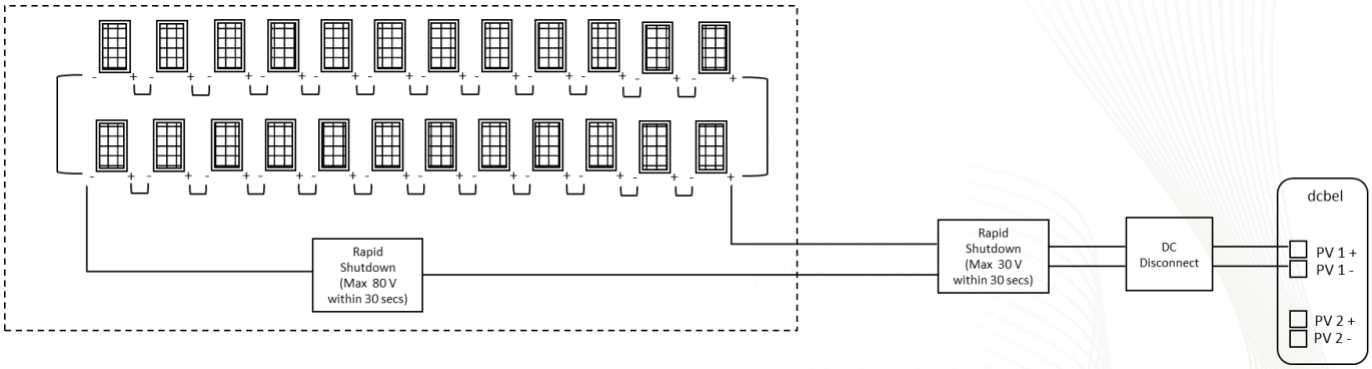


5.4.3 7,500 Watts configurations schematics

Sun Power SPR-X22-360: 7 500 W with 21 panels (3 string of 7 panels in series)

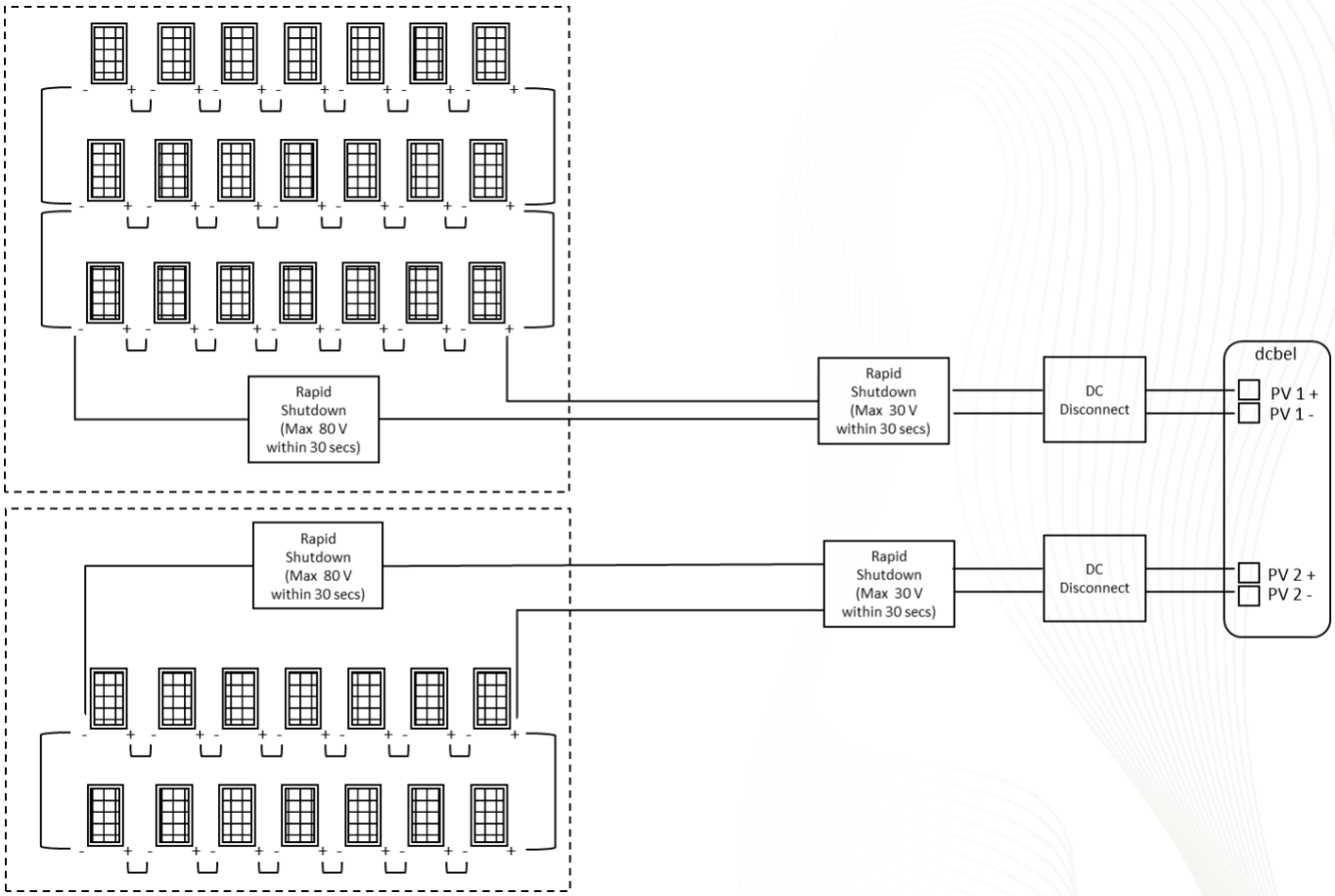


Canadian Solar CS6X-300P: 7 500 W with 24 panels (2 string of 12 panels in series)

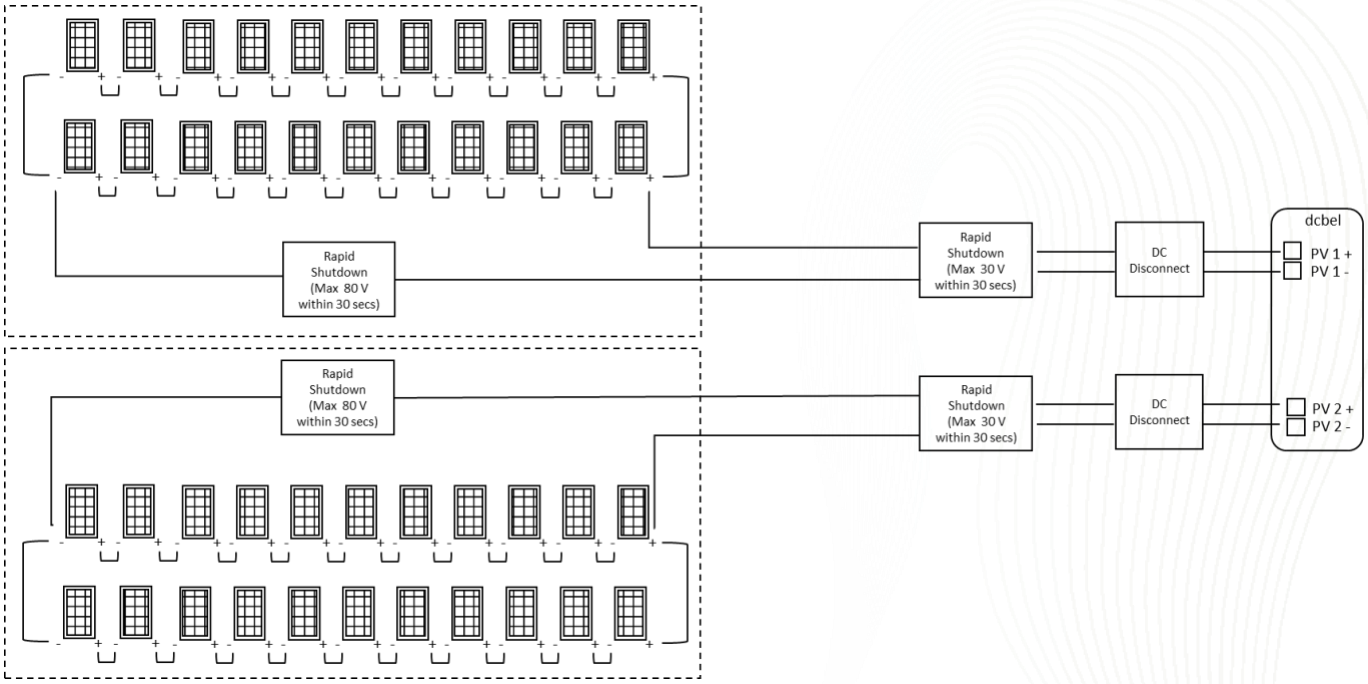


5.4.4 10,000 Watts configurations schematics

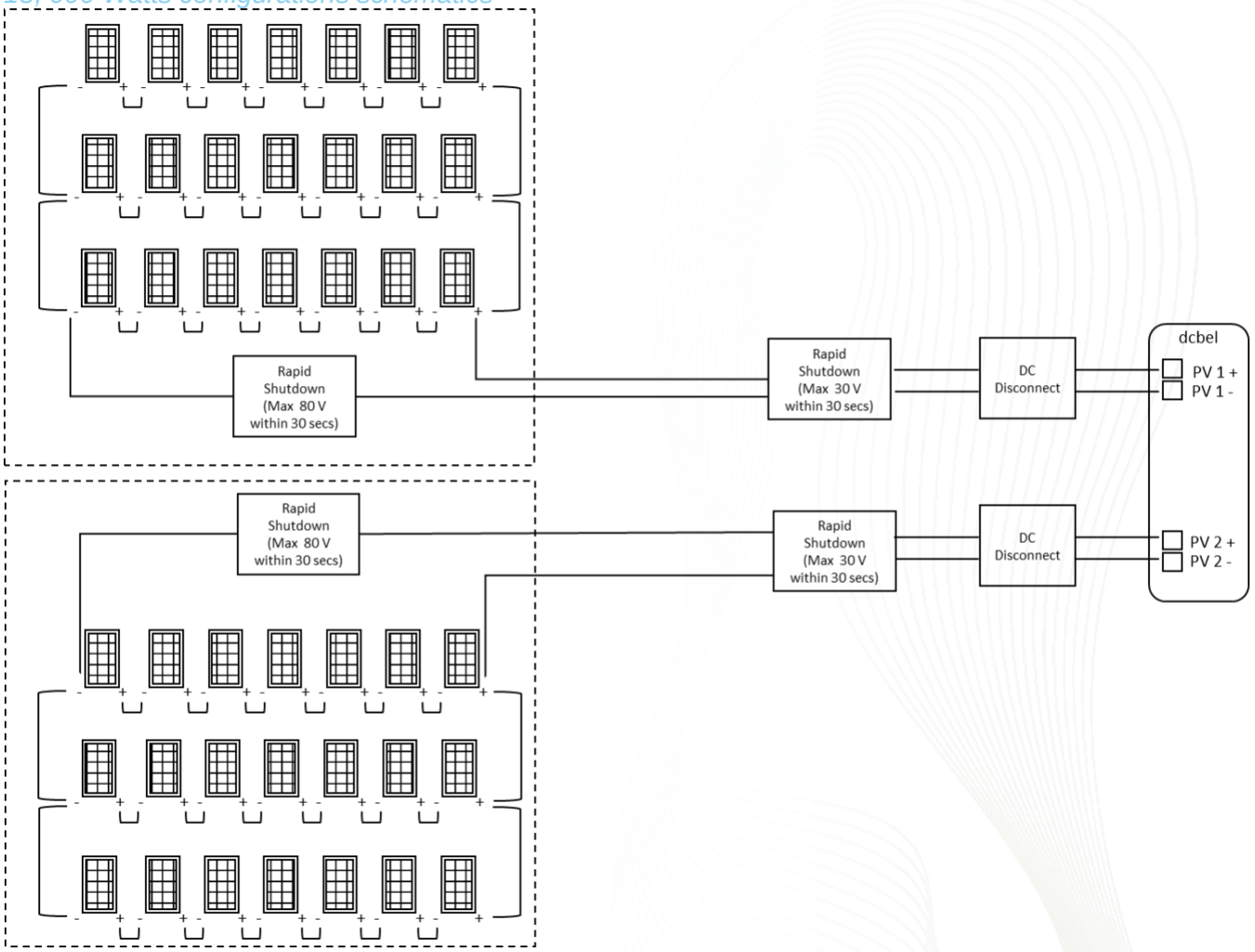
Sun Power SPR-X22-360: 10,000 W with 35 panels (5 string of 7 panels in series)



Canadian Solar CS6X-300P: 10,000 W with 44 panels (4 string of 11 panels in series)

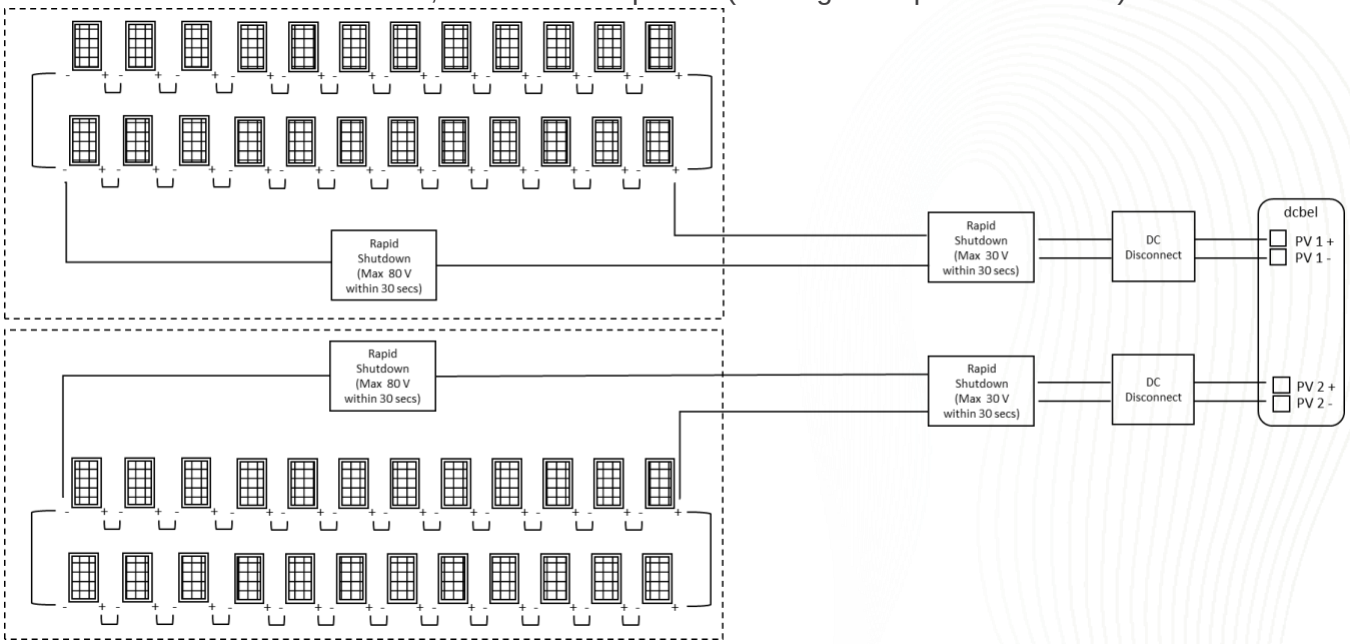


5.4.5 15. 000 Watts configurations schematics



Sun Power SPR-X22-360: 15.000 W with 42 panels (6 string of 7 panels in series)

Canadian Solar CS6X-300P: 15,000 W with 48 panels (4 string of 12 panels in series)



6 Rapid Shutdown Regulation

Below is an extract from the USA National Electrical Code (NEC) regarding rapid shutdown systems. Installers must also follow local regulations regarding the PV Rapid Shutdown requirements.

dcbel is compatible with all rapid shutdown devices that are compliant with NFPA 70 2020 article 690.12. However, not all rapid shutdown devices are designed to be universally compatible with all inverter brands.

6.1 NEC 2017 690.12 Rapid Shutdown Standard

The information below is an extract of article 690.12.

- All controlled conductors within 305 mm (1 ft) of the Solar panel array boundaries shall be limited to no more than 80 V within 30 seconds after the rapid shutdown initiation;
- All controlled conductor outside 305 mm (1 ft) of the Solar panel array boundaries shall be limited to no more than 30 V within 30 seconds after the rapid shutdown initiation;
- These requirements apply only to Solar panel arrays and inverters installed on or in a building;
- Rapid shutdown can be initiated with at least one of the following:
    - Building main service disconnecting means (Service panel main breaker);
    - PV system disconnecting means (String Inverter Disconnect);
    - Dedicated Solar panel array disconnect means.

- Rapid shutdown devices and systems **DO NOT REPLACE** the required physical PV system disconnect switch.

6.2 Rapid Shutdown Devices Compatible with dcbel™:

Below is a list of rapid shutdown devices that are compatible with dcbel™ (for reference only and subject to change without notice):

- Tigo Energy TS4-F or TS4-S
- IMO Fire Raptor
- MidNite Solar SOB
- ZJBeny BFS Series

7 Detailed Methodology for Determining the Size of a Solar Panel Array

This section presents all data, specifications and formulas for calculating the configurations presented in Section 5.3. Calculation examples are also provided.

7.1 dcbel™ Solar Inverter Input Specifications

dcbel™ solar inverter specifications used for these sizing examples are presented below:

Maximum Input Peak DC Power:	20,000 Watts Peak
Open Circuit Voltage:	600 V
MPPT Operating Voltage Range:	240 – 500 V
Short Circuit Current:	28 A per MPPT
Max Operating Current:	19 A per MPPT
Number of MPPT:	2

For complete dcbel™ specifications see: https://www.dcbel.energy/wp-content/uploads/ossiaco-data-sheet-2021.pdf

7.2 Locations

Three locations in California were selected for these sizing examples: the San Diego Area, the Los Angeles Area and the San Francisco Area.

More specifically, the design temperatures of these three locations for solar panel sizing are presented below:

Location #1:	San Diego Area
Temperature daily average (2% DB avg):	26 °C
Temperature Extreme Minimum:	5 °C

Location #2:	Los Angeles Area
Temperature daily average (2% DB avg):	26 °C
Temperature Extreme Minimum:	4 °C

Location #3: San Francisco Area

Temperature daily average (2% DB avg): 25 °C
Temperature Extreme Minimum: 2 °C

Design temperatures for these locations were obtained from the Solar America Board for Codes and Standards Website which provides data for most major cities in the U.S.A:

www.solarabcs.org/about/publications/reports/expedited-permit/map/index.html

7.3 Solar panels models and specifications

Two typical models of solar panels were used for these sizing examples: a 360 Watts from Sun Power and a 300 Watts from Canadian Solar.

More specifically, the specifications of these panels are presented below:

Sun Power:	SPR-X22-360	Rated Maximum Power:	360 W
Open Circuit Voltage:	69.5 V	Max Power Point Voltage:	59.1 V
Short Circuit Current:	6.48 A	Max Power Point Current:	6.09 A
Current Temp Factor:	0.0348 %A/°C	Voltage Temp Factor:	-0.2852 %V/°C
Power Temp Factor:	-0.3509 %/°C		

Canadian Solar:	CS6X-300P	Rated Maximum Power:	300 W
Open Circuit Voltage:	44.6 V	Max Power Point Voltage:	36.1 V
Short Circuit Current:	8.87 A	Max Power Point Current:	8.30 A
Current Temp Factor:	0.0474 %A/°C	Voltage Temp Factor:	-0.3071 %V/°C
Power Temp Factor:	-0.4002 %/°C		

7.4 Calculation Formulas and Examples

This section presents the formulas used to compute the results presented in the tables of the previous section.

Maximum number of panels in series in a string:

$$Max\ Nb\ Panels\ in\ series = Floor\left(\frac{Inverter\ Voc}{Panel\ Voc\ derated}\right)$$

Where,

Inverter *Voc* is the inverter's open circuit voltage;

Panel *Voc* derated is the solar panel open circuit voltage derated for the maximum extreme temperature of the location;

Voc derating is obtained using the voltage correction factors table 690.7(A) from the NFPA 70 2020, article 690.7, as shown below:

Min. Temp. (°C)	NEC Cold Factor	Min. Temp. (°F)
24 to 20	1.02	76 to 68
19 to 15	1.04	67 to 59
14 to 10	1.06	58 to 50
9.5	1.08	49 to 41

4 to 0	1.10	40 to 32
-1 to -5	1.12	31 to 23
-6 to -10	1.14	22 to 14
-11 to -15	1.16	13 to 5
-16 to -20	1.18	4 to -4
-21 to -25	1.20	-5 to-13
-26 to -30	1.21	-14 to -22
-31 to -35	1.23	-23 to -31
-36 and below	1.25	-32 and below

.

For example, dcbel™ Voc = 600 V, the CS6X-300P Voc = 44.6, and the extreme minimum temperature in Los Angeles = 4 °C. Thus, Voc derated = 44.6 * 1.10 = 49.06 V

$$Max\ Nb\ Panels\ in\ series = Floor\left(\frac{600}{49.06}\right) = Floor(12.22) = 12$$

Maximum number of strings in parallel on one MPPT:

$$Max\ Nb\ string\ in\ parallel\ per\ MPPT = Floor\left(\frac{Inverter\ Isc}{1.25 * Panel\ Isc}\right)$$

Where,

Inverter Isc is the inverter's short circuit current;

Panel Isc the solar panel short circuit current;

Isc derating is obtained using the 1.25 factors as required by NFPA 70 2020, article 690.8 (A)(1).

For example, dcbel™ Isc = 28 A per MPPT, the SPR-X22-360 Isc = 6.48 A. Thus, Isc derated = 8.1 A

$$Max\ Nb\ string\ in\ parallel\ per\ MPPT = Floor\left(\frac{28}{8.1}\right) = Floor(3.46) = 3$$