



# Cable Selection in small Off-grid Solar Energy Installations



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### Design to minimise Voltage Drop

Ideally, voltage drop in a solar energy installation should be < 2%. To keep costs down the cables recommended in this guide are designed to ensure voltage drop < 3%. Voltage drop should always be kept below 5%

**Calculation for the minimum cable section to ensure voltage drop < 3% =**  
 **$(0.0172 \times \text{distance, m} \times 200 \times \text{max. Amps}) / (\text{Voltage} \times 3)$**

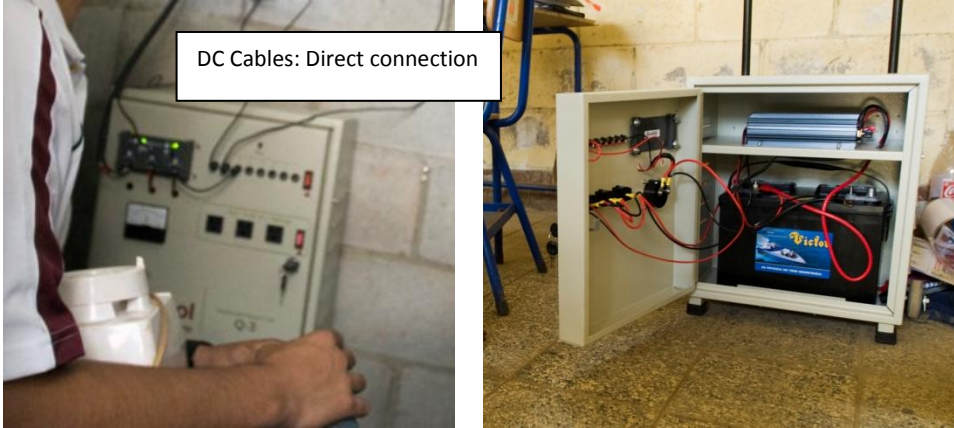
Distance = Total cable distance along its path (without including both the positive and the negative.) Cables with a voltage drop > 3% are only recommended in this guide if the ideal section corresponds to an odd numbered #AWG. Only even numbered #AWG cables are supplied in Guatemala (this guide is primarily written for the Guatemalan company Quetsol).

### 4W and 6W DC bulbs: Cable Selection (Solar Kits and Personalized Installations.)

Quetsol provides Off-grid solar installations with Kits or bespoke individual design. Individual design is for systems larger than 75W or 100W. The 'Kits' feature a box complete with the Regulator, Inverter and Battery. The Box has DC sockets to plug in the cables from the bulbs directly. Therefore each DC lighting cable has the current of just one bulb.



**Quetsol 75W Kit: Box for the battery, Regulator and Inverter.**



**10W, 30W and 75W Solar Kits (1 cable per bulb). Battery to 4W DC bulb: cable section for voltage drop < 3%**

**4W bulb: 12V, 0.333A**

Distance (kit/ battery to bulb), m	Ideal cable section (for voltage drop < 3%), mm <sup>2</sup>	Minimum recommended wire gauge, #AWG	Voltage drop if it's > 3% (%)
10	0.32	22	
15	0.48	20	
20	0.64	20	3.7

**10W, 30W and 75W Solar Kits (1 cable per bulb). Battery to 6W DC bulb: cable section for voltage drop < 3%**

**6W bulb: 12V, 0.5A**

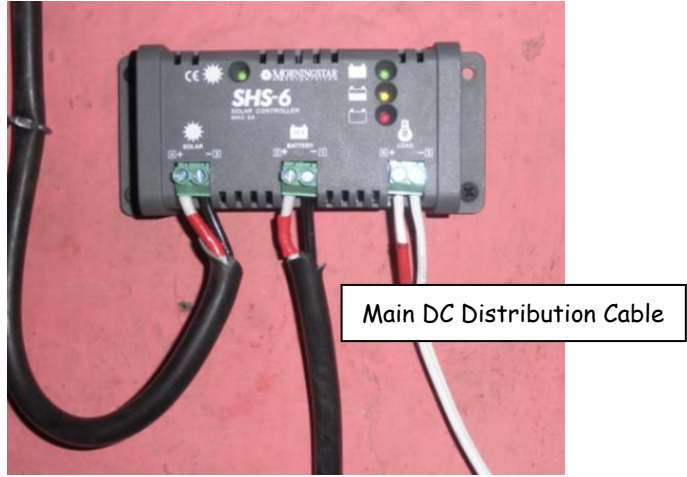
Distance (kit/ battery to bulb), m	Ideal cable section (for voltage drop < 3%), mm <sup>2</sup>	Minimum recommended wire gauge, #AWG	Voltage drop if it's > 3% (%)
10	0.48	20	
15	0.72	18	
20	0.96	18	3.5

**Individually designed installations (75W or larger): main DC distribution cable for lighting.**

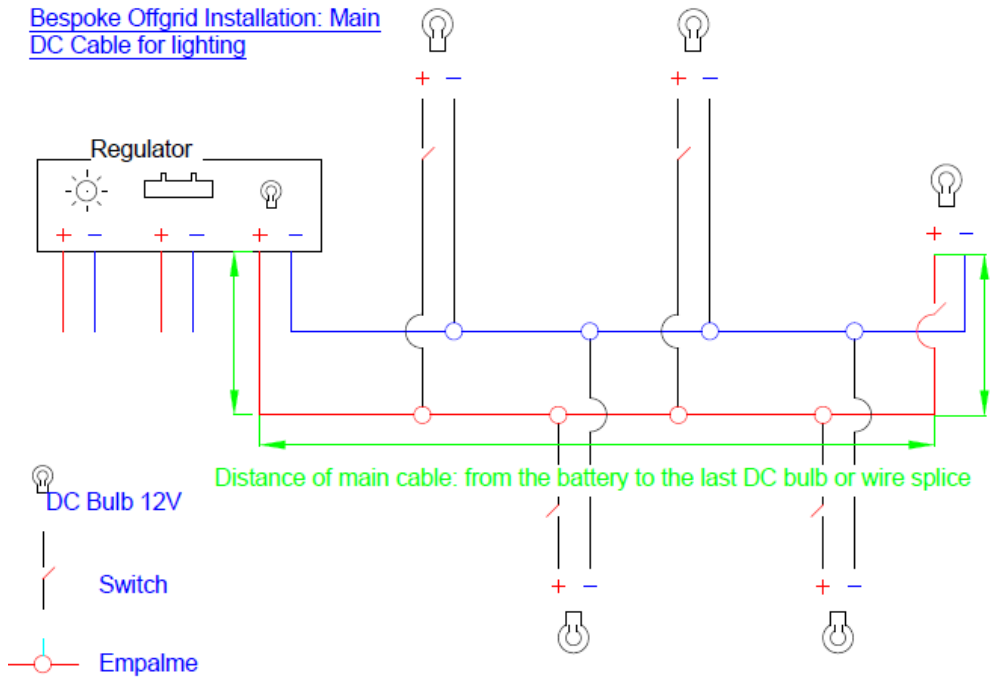
For traditional solar energy installations the DC loads gave just one main connection to the Regulator. The Cable from the Regulator is the main DC lighting cable. It should be designed to carry the current of all the bulbs switched on at once.



**Regulator (Charge Controller) in an individually designed solar system (not a Kit.)**



Bespoke Offgrid Installation: Main DC Cable for lighting



**7 DC bulbs (4W)**

**4W bulb: 12V, 0.333A**

7 bulbs - max Amps: 2.31 A

Distance (kit/ battery to last of 7 bulbs), m	Ideal cable section (for voltage drop < 3%), mm <sup>2</sup>	Minimum recommended wire gauge, #AWG	Voltage drop if it's > 3% (%)
10	2.21	14	3.2
15	3.31	12	
20	4.41	10	
30	6.62	10	3.8
40	8.83	8	3.2



### 7 DC bulbs (6W)

**6W bulb: 12V, 0.5A**

7 bulbs - max. Amps: 3.5A

Distance (kit/ battery to last of 7 bulbs), m	Ideal cable section (for voltage drop < 3%), mm <sup>2</sup>	Minimum recommended wire gauge, #AWG	Voltage drop if it's > 3% (%)
10	3.34	12	
15	5.02	10	
20	6.69	10	3.8
30	10.03	8	3.6
40	13.38	6	

### 5 DC bulbs (4W)

**4W bulbs: 12V, 0.333A**

5 bulbs - max. Amps: 1.65 A

Distance (kit/ battery to last of 5 bulbs), m	Ideal cable section (for voltage drop < 3%), mm <sup>2</sup>	Minimum recommended wire gauge, #AWG	Voltage drop if it's > 3% (%)
10	1.58	16	3.6
15	2.37	14	3.4
20	3.15	12	
30	4.73	10	
40	6.31	10	3.6

### 5 DC bulbs (6W)

**6W bulb: 12V, 0.5A**

5 bulbs - max amps: 2.5A

Distance (kit/ battery to last of 5 bulbs), m	Ideal cable section (for voltage drop < 3%), mm <sup>2</sup>	Minimum recommended wire gauge, #AWG	Voltage drop if it's > 3% (%)
10	2.39	14	3.4
15	3.58	12	3.2
20	4.78	10	
30	7.17	8	
40	9.56	8	3.4

### Cable from the Solar Panel to the Battery.

Calculation for the minimum cable section to ensure voltage drop < 3% =

$$(0.0172 \times \text{distance, m} \times 200 \times \text{max. Amps}) / (\text{Voltage} \times 3)$$

The Solar Panel's Imp is used for Amps (max), y Vmp for Voltage. Isc and VOC could be used for more conservative design.



Distance = Total cable distance along its path (without including both positive and negative.) In this context the **Regulator** represents part of the path between the Panel and the Battery.

### Installation of 1 Panel SH - 10S5 (10W): Cable Selection

With a different type of 10W panel the cable sections need to be re-calculated.

Module	Pmax	Vmp	Imp	Voc	Isc
SH - 10S5	10	17.8	0.562	22.2	0.601

#### Solar Panel SH - 10S5 to battery: cable section for voltage drop < 3%

Distance (Solar Panel to Battery), m	Ideal cable section (for voltage drop < 3%), mm <sup>2</sup>	Minimum recommended wire gauge, #AWG	Voltage drop if it's > 3% (%)
10	0.36	20	
15	0.54	18	
20	0.72	18	
30	1.09	16	
40	1.45	14	

### Installation of 1 Panel SH - 30S5 (30W): Cable Selection

With a different type of 30W panel the cable sections need to be re-calculated.

Module	Pmax	Vmp	Imp	Voc	Isc
SH-30S5	30	17.2	1.75	21.8	1.85

#### SH - 30S5 Solar Panel to battery: cable section for voltage drop < 3%

Distance (Solar Panel to Battery), m	Ideal cable section (for voltage drop < 3%), mm <sup>2</sup>	Minimum recommended wire gauge, #AWG
10	0.36	20
15	0.54	18
20	0.72	18
30	1.09	16
40	1.45	14

### Installation of one SH - 75S5 Panel (75W): Cable Selection

With a different type of 75W panel the cable sections need to be re-calculated.

Module	Pmax	Vmp	Imp	Voc	Isc
SH-75S5	75	16.1	4.659	19.8	5.261

#### SH-75S5 Solar Panel to Battery: cable section for voltage drop < 3%

Distance (Solar Panel to Battery), m	Ideal cable section (for voltage drop < 3%), mm <sup>2</sup>	Minimum recommended wire gauge, #AWG	Voltage drop if it's > 3% (%)
10	3.32	12	
15	4.98	10	



20	6.64	10	3.8
30	9.95	8	3.6
40	13.27	6	

All cables are above the minimum #AWG for THWN according to Current Carrying Capacity  
(*Fotovoltaica Manual de Diseño y Instalación, Solar Energy International: Table 9-4.*)

**Minimum AWG: 14**

**Amps for calculation: 8.22A**

### Installation of one Zytec ZT100P Solar Panel (100W): Cable Selection

With a different type of 100W solar panel the cable sections need to be re-calculated.

Module	Pmax	Vmp	Imp	Voc	Isc
ZT100P	100	17.97	7.56	14.64	6.83

#### ZT100P Solar Panel to battery: cable section for voltage drop < 3%

Distance (Solar Panel to Battery), m	Ideal cable section (for voltage drop < 3%), mm <sup>2</sup>	Minimum recommended wire gauge, #AWG	Voltage drop if it's > 3% (%)
10	4.82	10	
15	7.24	8	
20	9.65	8	3.5
30	14.47	6	3.3
40	19.30	4	2.7

All cables are above the minimum #AWG for THWN according to Current Carrying Capacity  
(*Fotovoltaica Manual de Diseño y Instalación, Solar Energy International: Table 9-4.*)

**Minimum AWG: 14**

**Amps for calculation: 10.67A**

### Installation of one Zytec ZT150P Solar Panel (150W): cable selection

With a different type of 75W panel the cable sections need to be re-calculated.

Module	Pmax	Vmp	Imp	Voc	Isc
ZT150P	150	25.45	7.86	21.17	7.32

#### Panel Solar ZT150P a Batería: sección de cable para caída de voltaje < 3%

Distance (Solar Panel to Battery), m	Ideal cable section (for voltage drop < 3%), mm <sup>2</sup>	Minimum recommended wire gauge, #AWG	Voltage drop if it's > 3% (%)
10	3.54	12	3.2
15	5.31	10	
20	7.08	10	2.5
30	10.62	6	2.4
40	14.17	6	3.2



All cables are above the minimum #AWG for THWN according to Current Carrying Capacity (*Fotovoltaica Manual de Diseño y Instalación, Solar Energy International: Table 9-4.*)

**Minimum AWG: 14**

**Amps for calculation: 11.44A**

### Installation of one Evergreen ES - E215W Solar Panel (215W): cable selection

With a different type of 215W panel the cable sections need to be re-calculated.

Module	Pmax	Vmp	Imp	Voc	Isc
ES-E215W	215	29	7.43	35.6	8.12

#### ES-E215W Solar Panel to battery: cable selection for voltage drop < 3%

Distance (Solar Panel to Battery), m	Ideal cable section (for voltage drop < 3%), mm <sup>2</sup>	Minimum recommended wire gauge, #AWG	Voltage drop if it's > 3% (%)
10	2.94	12	
15	4.41	10	
20	5.88	10	3.4
30	8.81	8	3.2
40	11.75	6	

All cables are above the minimum #AWG for THWN according to Current Carrying Capacity (*Fotovoltaica Manual de Diseño y Instalación, Solar Energy International: Table 9-4.*)

**Minimum AWG: 14**

**Amps for calculation: 12.69A**

### Installation of one Sharp NU-U235F2 Solar Panel (235W): cable selection

With a different type of 235W panel the cable sections need to be re-calculated.

Module	Pmax	Vmp	Imp	Voc	Isc
NU-U235F2	235	30	7.84	37	8.6

#### ES-E215W to battery: caable section for voltage drop < 3%

Distance (Solar Panel to Battery), m	Ideal cable section (for voltage drop < 3%), mm <sup>2</sup>	Minimum recommended wire gauge, #AWG	Voltage drop if it's > 3% (%)
10	3.00	12	
15	4.49	10	
20	5.99	10	3.4
30	8.99	8	3.2
40	11.99	6	

All cables are above the minimum #AWG for THWN according to Current Carrying Capacity (*Fotovoltaica Manual de Diseño y Instalación, Solar Energy International: Table 9-4.*)

**Minimum AWG: 14**





Amps for calculation: 13.44A

### Cables between the Inverter and the Battery. AC load cables.

Inverters usually come supplied with their cables. If not, refer to manufacturers' instructions.

AC load cables should be dimensioned in the same way to keep voltage drop below 3%:

Calculation for the minimum cable section to ensure voltage drop < 3% =  
 $(0.0172 \times \text{distance, m} \times 200 \times \text{max. Amps}) / (\text{Voltage} \times 3)$

### Table of AWG Wire sizes

AWG	Section, mm <sup>2</sup>	AWG	Section, mm <sup>2</sup>	AWG	Section, mm <sup>2</sup>	AWG	Section, mm <sup>2</sup>
1	42.4	8	8.37	16	1.31	23	0.258
2	33.6	9	6.63	17	1.04	24	0.205
3	26.7	10	5.26	18	0.823	25	0.162
4	21.2	11	4.17	19	0.653	26	0.129
5	16.8	12	3.31	20	0.518	27	0.102
6	13.3	13	2.62	21	0.41	28	0.081
7	10.5	14	2.08	22	0.326	29	0.0642

[http://en.wikipedia.org/wiki/American\\_wire\\_gauge](http://en.wikipedia.org/wiki/American_wire_gauge)