Tech Tips

FRANKEN SOLAR AMERICAS

Off-Grid - How many solar panels do I need?

Overview:

Selecting the right PV system size for your off-grid system is a critical step for a reliable system to power your loads when you need them. There are multiple ways to determine/predict the production of a future installation.

In the following steps we'll discuss a few easy-to-use methods that do not require any third-party, fee-based software tools. We will be using data from the Natural Resources Canada databases, free of charge.

Natural Resources Canada Ressources naturelles Canada

Canada

There are 4 main factors that determine directly or indirectly, the energy production of a solar installation:

- a.) Location
- b.) Orientation
- c.) Inclination/Angle
- d.) Possible shading conditions

Often the ideal location or orientation cannot be achieved, so a compromise is necessary. Compared to other system components of an off-grid system, solar panels are very affordable and by slightly increasing the system size, limitations due to partial shading or not ideal orientation can be compensated for.

Follow along with our 7-step off-grid solar sizing guide:

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Step 1:

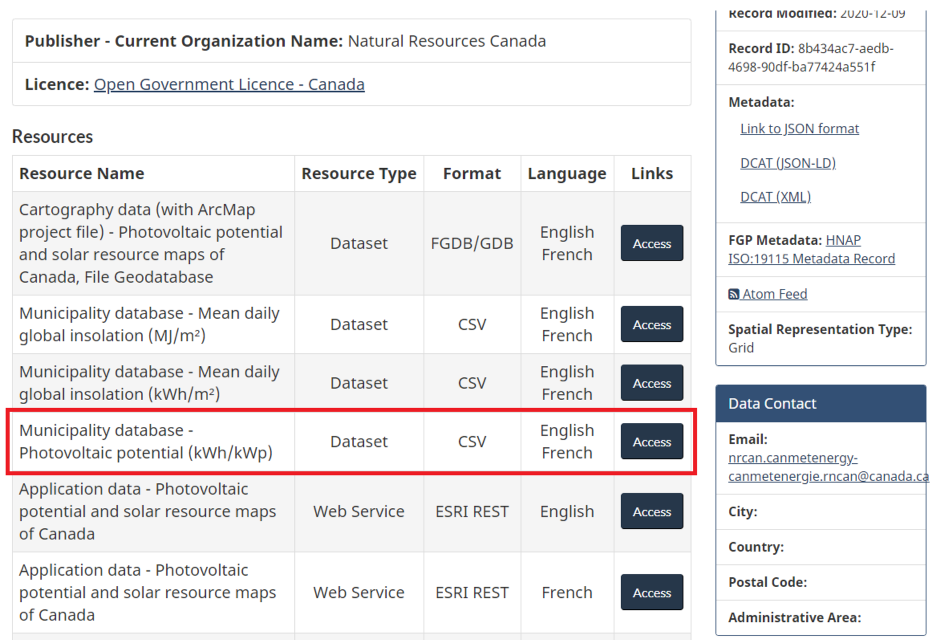
Collect data about your application and location:

a.) What is the location of the system? (Latitude) e.g. Four Mile Lake, ON, Latitude 44°
b.) What is the closest (large) municipality? e.g. Kawartha Lakes, ON
c.) What is the inclination of an available roof? e.g. 6/12 pitch or 26deg
d.) What is the expected daily load in the summer? e.g. 2500Wh or 2.5kWh per day
e.) What is the expected daily load in the winter? e.g. 3400Wh or 3.4kWh per day

Step 2:

Go to the Government of Canada website via the following link:
https://open.canada.ca/data/en/dataset/8b434ac7-aedb-4698-90df-ba77424a551f

Scroll down and select 'Municipality database – Photovoltaic potential (kWh/kWp)' CSV dataset:



Publisher - Current Organization Name: Natural Resources Canada

Licence: Open Government Licence - Canada

Resources

Resource Name	Resource Type	Format	Language	Links
Cartography data (with ArcMap project file) - Photovoltaic potential and solar resource maps of Canada, File Geodatabase	Dataset	FGDB/GDB	English French	Access
Municipality database - Mean daily global insolation (MJ/m²)	Dataset	CSV	English French	Access
Municipality database - Mean daily global insolation (kWh/m²)	Dataset	CSV	English French	Access
Municipality database - Photovoltaic potential (kWh/kWp)	Dataset	CSV	English French	Access
Application data - Photovoltaic potential and solar resource maps of Canada	Web Service	ESRI REST	English	Access
Application data - Photovoltaic potential and solar resource maps of Canada	Web Service	ESRI REST	French	Access

Record Modified: 2020-12-09

Record ID: 8b434ac7-aedb-4698-90df-ba77424a551f

Metadata:
Link to JSON format
DCAT (JSON-LD)
DCAT (XML)

FGP Metadata: HNAP ISO:19115 Metadata Record

Atom Feed

Spatial Representation Type: Grid

Data Contact

Email: nrcan.canmetenergy-canmetenergie.rncan@canada.ca

City:

Country:

Postal Code:

Administrative Area:

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The database .csv file can be opened with Microsoft Excel, Google Sheets, or any LibreOffice Calc program.

	A	B	C	D	E	F	G	H	I	J	K	L
1				Photovolt	Photovolt	Photovolt	Photovolt	Photovolt	Photovoltaic potential (kWh/kWp)			
2				Potentiel	Potentiel	Potentiel	Potentiel	Potentiel	Potentiel photovoltaïque (kWh/kWp)			
3	Province	Municipal	Mois	South-faci	South-faci	South-faci	South-faci	2-axis trac	Horizontal (0 degree)			
4	Province	Municipal	Month	Vertical o	Orienté v	Orienté v	Orienté v	Suivi du s	Horizontal (inclinaison=0 degré)			
5	Alberta/A	Acadia Va	January/Ja	88	83	89	72	100	29			
6	Alberta/A	Acadia Va	February/	98	100	104	91	123	47			
7	Alberta/A	Acadia Va	March/Ma	111	130	128	125	167	84			
8	Alberta/A	Acadia Va	April/Avri	92	130	120	134	190	112			
9	Alberta/A	Acadia Va	May/Mai	78	130	114	141	211	136			
10	Alberta/A	Acadia Va	June/Juin	72	128	109	142	219	142			
11	Alberta/A	Acadia Va	July/Juille	80	139	120	153	236	151			
12	Alberta/A	Acadia Va	August/Ac	89	138	124	145	214	127			
13	Alberta/A	Acadia Va	Septembe	92	119	114	119	164	86			
14	Alberta/A	Acadia Va	October/C	101	112	113	104	141	56			
15	Alberta/A	Acadia Va	Novembe	80	78	83	69	94	29			
16	Alberta/A	Acadia Va	Decembei	72	67	73	58	81	22			
17	Alberta/A	Acadia Va	Annual/Ai	1054	1355	1289	1353	1941	1021			
18	Alberta/A	Acme	January/Ja	84	80	85	69	95	26			
19	Alberta/A	Acme	February/	92	94	97	86	115	44			
20	Alberta/A	Acme	March/Ma	106	124	122	120	159	82			
21	Alberta/A	Acme	April/Avri	90	127	117	131	184	109			

Column A and column B list all municipalities in Canada

Row 3 lists different tilt angles with a directly south-facing orientation

The six available options are:

- Column D: South-facing with vertical tilt (90 degrees)
- Column E: South-facing with latitude tilt (in our example 44°)
- Column F: South-facing with tilt=latitude+15 degrees (in our example 59°)
- Column G: South-facing with tilt=latitude-15 degrees (in our example 29°)
- Column H: 2-axis tracking (not applicable to our example)
- Column I: Horizontal (0 degree)

Step 3:

Search for your municipality by pressing ‘CTRL+F’

(e.g. Kawartha Lakes)

Select the appropriate column for the type of installation

(e.g. Column G for latitude-15deg for our ~26deg tilt 6/12 pitch)

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	A	B	C	D	E	F	G	H	I	J
1				Photovolt	Photovolt	Photovolt	Photovolt	Photovolt	Photovoltaic potential (	
3	Province	Municipality	Mois	South-faci	South-faci	South-faci	South-faci	2-axis trac	Horizontal (0 degree)	
26433	Ontario/Ontario	Kashabowie	Annual/Ai	936	1231	1170	1229	1747	966	
26434	Ontario/Ontario	Kawartha Lakes	January/J	71	69	74	61	84	35	
26435	Ontario/Ontario	Kawartha Lakes	February/	82	86	89	79	105	52	
26436	Ontario/Ontario	Kawartha Lakes	March/Ma	94	116	114	112	148	84	
26437	Ontario/Ontario	Kawartha Lakes	April/Avri	73	115	106	119	162	101	
26438	Ontario/Ontario	Kawartha Lakes	May/Mai	66	123	108	132	186	126	
26439	Ontario/Ontario	Kawartha Lakes	June/Juin	59	121	104	134	196	135	
26440	Ontario/Ontario	Kawartha Lakes	July/Juille	64	128	110	140	206	142	
26441	Ontario/Ontario	Kawartha Lakes	August/A	68	118	106	125	174	118	
26442	Ontario/Ontario	Kawartha Lakes	Septembe	70	100	95	100	135	86	
26443	Ontario/Ontario	Kawartha Lakes	October/	73	87	87	82	108	58	
26444	Ontario/Ontario	Kawartha Lakes	Novembe	51	54	56	49	64	30	
26445	Ontario/Ontario	Kawartha Lakes	Decembe	56	54	58	48	65	27	
26446	Ontario/Ontario	Kawartha Lakes	Annual/A	826	1172	1107	1181	1634	994	
26447	Ontario/Ontario	Kearney	January/J	73	70	75	62	86	33	
26448	Ontario/Ontario	Kearney	February/	86	89	93	82	110	49	

Step 6:

Each system has inefficiencies and losses. These losses are related to power conversions in inverters or charge controllers but also in the type of battery storage you choose to install.

In addition to the losses the above calculations are considering daily averages. The solar system needs to be designed larger than just the size to cover the daily average.
/ there will be a rainy day on the next day, the solar system must provide energy to recharge the batteries from the day before as well as to provide power for the current day.

Every system is different and will have a different overall efficiency. A general rule of thumb is to account for about 20-25% system losses. For the recharging capabilities after a lower-than-average yield day a safety factor of roughly 30% is added to the system size.

This will lead to the following equation in the summer:

$$P_{PV-final}[kWp] = \frac{P_{PV}[kWp] * 130\%}{(1 - Sys_{loss})}$$

$$P_{PV-final}[kWp] = \frac{0.76 * 130\%}{(1 - 25\%)} = 1.32\ kWp$$

In a winter application with a higher daily consumption, the solar system size and linearly the cost of the system will increase significa ntly. A balance between all energy covered with solar (large, oversized solar array) and the runtime of a backup generator must be found.

Step 7:

Conclusion for mainly Summer Usage:

If the system is mainly used over the peak summer months, a 1 kW_{DC} system could be selected. This size would provide sufficient power in 95% of all summer month weather conditions. In the shoulder seasons, spring and fall, additional solar power would be helpful for a more robust operation of the system. e.g. 2kW_{DC}

Conclusion for mainly Winter Usage:

If this system would be used daily year-round, we would go back to step 2 of this manual and would see that specific yield over the winter month of a system at higher tilt angle (column F, 59deg) would be better suited. At the same time the higher tilt angle would not affecting the production in the summer month too much (higher yield due to larger array in addition to lower summer loads).

In such a scenario a ~3kW_{DC} solar system with an addition of a smaller backup generator would be the most suitable option.

Solar Sizing Rule of Thumb:

Summer:

for every watt-hour [Wh] of load, you need 0.5W_{DC} solar power
e.g. 2000Wh load => 1000W_{DC} or 1kW_{DC} solar power

Winter:

for every watt-hour [Wh] of load, you need 1W_{DC} solar power
e.g. 2000Wh load => 2000W_{DC} or 2kW_{DC} solar power

Disclaimer:

In off-grid design, every application and system are different. This guide is intended to educate off-grid users about their future system's production and help understand it's limitations.

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