

SOLAR FOR RANGER STATIONS

A PRACTICAL GUIDE TO IMPLEMENTING OFF-GRID SOLAR PHOTOVOLTAICS FOR PEOPLE AND NATURE

NOVEMBER 2026

CONTENTS

At a Glance 3

Introduction 4

Getting Started 7

Planning Your System 11

Designing Your System 14

Installing Your System 17

Maintaining and Monitoring Your System 19

Glossary 22

Acknowledgements

Principal Writers: Zoe Friese and Mengly Morn
Technical Editor: Jean-Philippe Denruyter
Principal Reviewers: Richard Scotney and Felix Safouet
French Translation: Ony Fy Andriambololona
Design and Infographics: Zoe Friese

We also give special thanks to the Universal Ranger Support Alliance steering committee and Dean Cooper for their thoughtful contributions and support.

For questions, please contact Jean-Philippe Denruyter at jdenruyter@wwf.eu.

Copyright WWF © 2026

Photo credits: Front cover & back cover © Zoe Friese / WWF-Cambodia



SOLAR FOR RANGER STATIONS

AT A GLANCE

INTRODUCTION

Solar PV technology is one of best tools for powering conservation.

- Understand why (pg. 5)
- See real stories of impact (pg. 5-6)

DESIGN

- Identify needed DC voltage and AC phases (pg. 14)
- Choose types of batteries and panels (pg. 15-16)
- Incorporate generator if needed (pg. 16)

GET STARTED

- Define solar processes, key components, and units of energy (pg. 7-8)
- Recruit a team lead (pg. 9)
- Understand costs and financing mechanisms (pg. 9-10)

INSTALL

- Navigate the call for proposals and tendering process (pg. 17)
- Put must-haves in your contract (pg. 18)
- Choose high-quality equipment brands (pg. 18)

PLAN

- Analyse your electricity demand (pg. 11)
- Consider needed appliances and energy efficiency (pg. 12)
- Look into infrastructure, location and policy environment (pg. 13)

MAINTAIN & MONITOR

- Plan for part replacements (pg. 19)
- Train staff, monitor performance and clean equipment (pg. 19–21)
- Implement an ownership and management model (pg. 21)

GLOSSARY

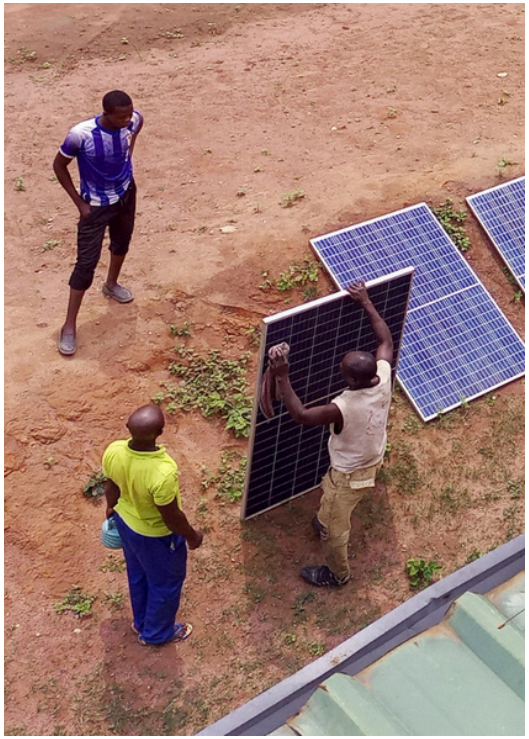
- Review key terms (pg. 22-23)

INTRODUCTION

The Inside Scoop on Solar

As the world's fastest growing energy source, solar photovoltaics (PV) is one of our best tools to power the conservation of nature. This technology can generate renewable power from virtually anywhere, giving us the resources to protect wildlife and habitats in rainforests, savannahs, mountains or coastlines. Reliable electricity allows rangers to work longer, researchers to use state-of-the-art equipment and communities to pursue sustainable livelihoods. But navigating a solar PV installation from start to finish isn't easy – and this is where we'd like to help.

At WWF, we spent more than 10 years learning how to harness the sun to energize conservation work and community livelihoods. We've implemented and monitored over 80 solar projects across five continents, including ranger stations, offices, field camps and community buildings. Over the years, we've seen it all – the good, bad and (sometimes) ugly realities of solar installations. Starting from scratch can feel overwhelming, so we're sharing what we know to make the journey a little easier.



This guidebook aims to support you in solarizing a ranger station, the beating heart of a protected area's conservation efforts. Ranger stations are often in highly remote locations, where limited energy access defines daily life. Some rangers spend days or weeks at a time on duty without fans, lights or phone chargers. For them, solar power means power to do their jobs effectively and fulfill their basic needs. With a reliable power supply, rangers can conduct patrols and monitor wildlife with better tools and working conditions.

Using some of our hard-earned knowledge, we hope that you can replicate solar successes and avoid the most common mistakes – without learning the hard way. This guidebook is not a complete list of everything you need to know, but it's a good place to start for non-technical perspectives on how to implement solar energy. Though this guidance focuses on ranger stations, similar principles will apply to small-scale, off-grid installations anywhere.



Technical guidance in this guidebook comes from WWF's Energizing Communities and Conservation team, a global programme accelerating implementation of renewable energy solutions.

© APDS / WWF-CAR

Why Solarize a Ranger Station?

Solar PV systems can provide a stable, autonomous energy source for lighting, communications and daily needs at a ranger station for 20+ years. Fuel generators, the go-to choice of the past, cannot compete with today's solar technology. Unlike diesel or petrol, sunlight is a resource you'll never need to pay for. Securing a constant supply of fuel is not only expensive but also a risk, given the challenges of transporting fuel to remote places. Burning fossil fuels also leaves you vulnerable to fuel shortages and geopolitical conflicts.

Solar energy grants peace of mind and a peaceful environment – they operate silently without the noise or fumes of generators. They are better for the health of people and our planet, and likely better for your wallet too. Compared to fuel generators, simple payback time can be as fast as three years – and in our experience, usually less than seven years.

In a remote location with limited access to technicians, maintenance needs are also a deciding factor. Fuel generators tend to break down regularly, causing frequent disruptions and visits from mechanics. Meanwhile, solar PV has little to no moving parts, reducing the cost and frequency of maintenance. This is also where solar outshines other renewable energy solutions. While wind and hydropower can function well in windy coastal areas or mountains (depending on weather patterns and topography), their moving parts involve serious ongoing maintenance. With these factors in mind, solar PV has become the most economic, dependable option for most ranger stations.

Real Conservation Impact

Solar solutions are practical, but importantly, they are also aligned with the goals and values of conservation. By switching away from fossil fuels, we reduce an existential threat to wildlife and habitats: planet-warming carbon emissions. At the same time, we improve the lives of the rangers protecting our most precious ecosystems. Here are a few examples of solar's impact:

1. Dzanga-Sangha Protected Areas, Central African Republic

As of 2025, 14 solar sites and counting are responsible for powering 98% of electricity in this Congo Basin park, supporting forest elephant research, gorilla habituation activities and a One Health lab. Solar also powers communications equipment at eco-guard bases, making 24/7 coordination across the park possible for the first time. In addition, communities have access to a local hospital, a football field and soon household electricity powered by solar.

"This type of success has convinced me that solar energy represents much more than an alternative: it is a viable, sustainable and essential solution for countries where access to electricity remains very limited."

Felix Safouet, Senior Renewable Energy Technician, WWF



© APDS / WWF-CAR

2. Phibsoo Wildlife Sanctuary, Bhutan

Though one of Bhutan's smallest and most remote wildlife sanctuaries, Phibsoo provides sanctuary for exceptional biodiversity like tigers, golden langurs, and endangered white-bellied herons. Park rangers were in the dark without electricity for decades. Now, a solar PV system supplies electricity to their main camp, and a solar-powered water pump draws groundwater for camp use and wildlife waterholes. Solar-powered surveillance cameras also support real-time wildlife monitoring and security.

"Extending the national grid to the camp would have required clearing an estimated 15km by 8m corridor through pristine forest, causing habitat fragmentation and long-term ecological disturbance. Solar energy has helped avoid this impact."

Dorji Rabten, Chief Forest Officer, Phibsoo Wildlife Sanctuary



© Phibsoo Wildlife Sanctuary

3. Mekong Flooded Forest, Cambodia

In 2025, WWF introduced a solar PV system to Prek Prasob Ranger Station, which helps protect the area's last remaining hog deer. Before the installation, rangers had no fans to stay cool and limited lighting at night. They relied on community members to help charge their phones. Now, they have electricity to support their daily needs and field operations, as well as a water pump for raising tree saplings.

"Our work has improved significantly thanks to the reliable electricity from the solar PV system. The lighting at the ranger stations has made us feel more secure and confident, as it deters poachers who might otherwise try to approach the area with bad intentions."

Leang Bunnary, Ministry of Environment ranger, Prek Prasob Wildlife Sanctuary





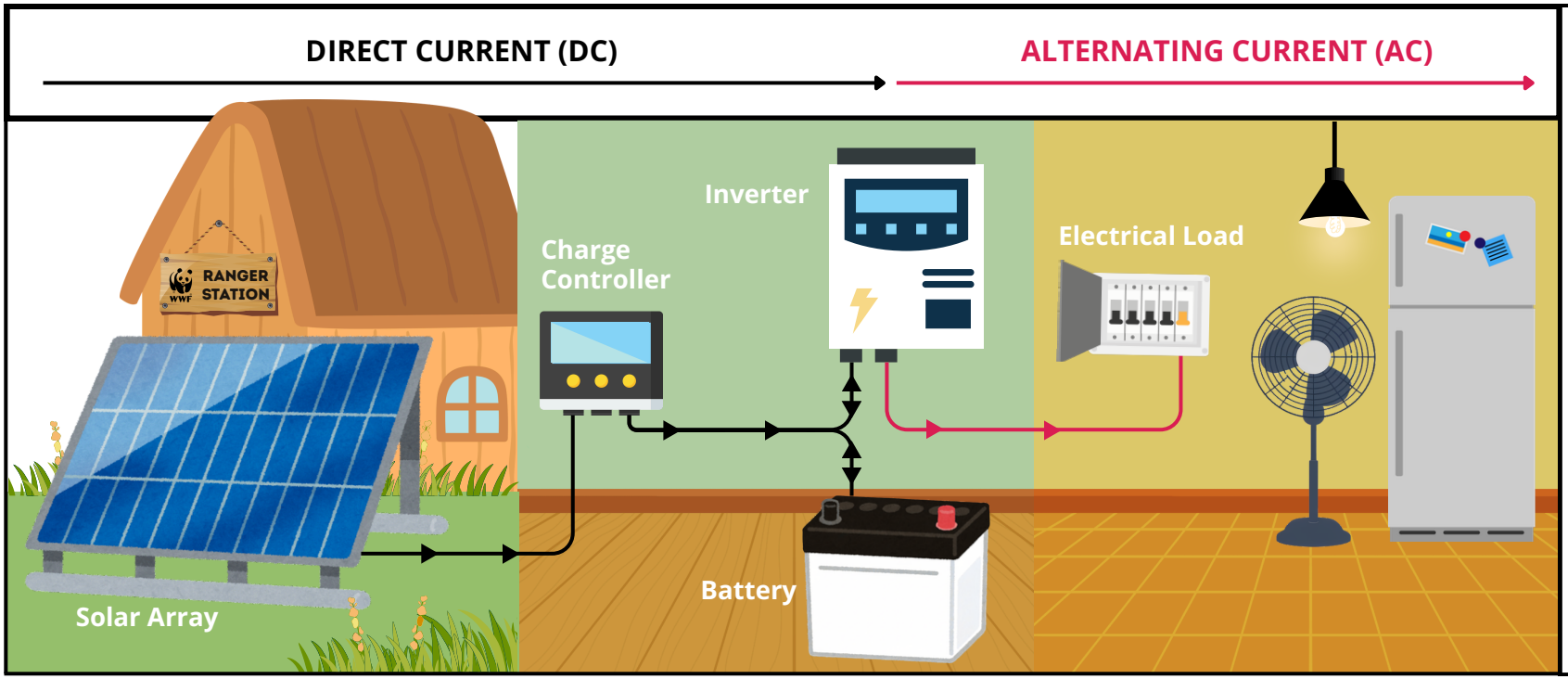
© Zoe Friese / WWF-Cambodia

GETTING STARTED

Solar 101: Defining Key Components

How do we make electricity from the sun with photovoltaics? When particles of sunlight called photons hit the semiconductors in a solar panel, they transfer their energy to the electrons within the material. The energy excites the electrons, kicking them into a higher energy state where they break free from their atoms. Free electrons then flow as an electrical current, producing energy through the so-called "photovoltaic effect."

Multiple solar panels, together called a solar array, will carry out the photovoltaic effect. But, we'll need some additional components to electrify a ranger station. The solar array generates direct current (DC) electricity, which flows only one way, while most appliances run on alternating current (AC) electricity that flows both ways. We need an inverter to convert DC to AC electricity – then, that power can be used to feed your electrical load (i.e. your household devices and appliances). Meanwhile, a battery can store extra energy produced during the daytime to use at night or on cloudy days. To protect your battery from overcharging, you'll also need a charge controller regulating the flow of energy from the solar array.



Solar Array (or solar panels):
Converts energy from sunlight into direct current (DC) electricity.

Charge Controller:
Regulates the solar charging of batteries in systems with battery storage to prevent overcharging.

Inverter (i.e. battery inverter):
Converts DC power into AC power for appliances to use.

Battery:
Stores extra electricity produced by solar panels to use when the sun isn't shining or at night.

Load:
The appliances using electricity (i.e. fans, lights, refrigerators).

All Turned Around On Inverters?

An inverter's main purpose is converting DC electricity into AC electricity. But, different kinds of inverters are needed for different kinds of solar PV systems – and their functions can vary. A "battery inverter" converts energy from your battery or solar electricity from the charge controller into AC. Meanwhile, an "inverter charger" can work in both directions, inverting DC to AC and AC to DC. This allows your batteries to recharge using grid-electricity or a generator. Other types of inverters, such as solar inverters, may also be suitable for your ranger station.

For simple definitions of terms used in this guidebook, check out our Glossary section.

A solar system's design will depend greatly on whether you have access to the electrical grid. Because most ranger stations are "off-grid" in the wilderness, a battery is essential for keeping the system running consistently. "On-grid" or "grid-tied" systems do not necessarily need batteries – instead, they can feed surplus electricity into the grid, if this is allowed, and take back electricity at night. It's also possible to have a "hybrid" system with grid connection and a back-up battery if the local grid is not reliable.

Watts What?

You'll notice different units are used for measuring different kinds of solar components.

- The size of your inverter will be in watts (W) or kilowatts (kW). These are "real" units of electric power produced by your system.
- Your solar array will be measured in kilowatt-peak (kWp), which shows maximum power output when conditions are ideal.
- The capacity of the battery will be in kilowatt hours (kWh) for lithium batteries or Ampere-hours (Ah) for lead-acid batteries. These values capture how long the system can operate over a span of time at a certain consumption rate.



This solar PV system, located at Prek Prasob Ranger Station in Cambodia, has a stand-alone 6.8kWp array capacity (top) with a 7kW battery-based inverter and a 20kWh battery capacity (bottom).

Building Your Team

There's one more key component to your solar system – a qualified team member that can lead the process! In our experience, having an in-house solar expert is an essential element for success. If you don't have an expert in your organization, we recommend hiring a consultant from the project's inception to the final commissioning, so you have technical backstopping each step of the way. This is a worthwhile investment: relying only on online resources, such as AI, rather than real field expertise will leave your team unequipped to oversee the quality of equipment, installers and their designs.

Your in-house expert or consultant should also be present during the solar plant's construction to ensure good practices are followed.

Ideally, your organization can recruit a solar or renewable energy director who manages all renewable energy projects in your organization. This would allow for stronger knowledge management and sharing throughout the organization as well as consistent monitoring and maintenance of solar systems. It's also easier to continue relationships with skilled solar installers and identify preferred equipment brands to use over time.

Understanding Cost and Financing

Total cost of the solar installation will depend on location, equipment costs as well as local solar policies and subsidies. In our experience, solarizing a medium-size ranger station (like the example above) costs about 20,000–30,000 EUR. This includes two years of maintenance and troubleshooting.

This cost may not represent the cheapest in the market, but with slightly higher upfront expenditure, rangers will gain high-quality equipment and long warranties, with lower costs of future maintenance and troubleshooting. This point is especially important for remote ranger stations, where maintenance and troubleshooting services may be far away. Furthermore, for organizations with changing funding cycles, there's little guarantee of a high budget for future equipment replacements – so investing in a high-quality installation and equipment upfront is wise.

As a non-governmental organization (NGO), we've explored four financing mechanisms for solar projects: organizational development, internal emissions reductions, loan programmes and project funding.



Organizational development funding: Large organizations like WWF often have funding set aside for investing in internal infrastructure, from our urban offices to rural ranger stations. Most of WWF's internal operations projects are funded this way, often with fewer restrictions and regulations than other financing methods. However, smaller organizations that rely only on project funding may not benefit from such arrangements.

Internal emissions reduction efforts: Many organizations now strive to reduce carbon emissions within their operations, with some setting an internal carbon price that helps fund emissions reduction activities. This practice is increasingly popular as organizations shift away from purchasing carbon credits that 'offset' impact, instead focusing inwardly on 'insetting'. Solarizing on-the-ground activities can be a great pathway for reducing your carbon footprint, particularly when dedicated funds are available to do so.

Loan programmes: When done right, solar PV technology pays for itself overtime – savings on energy bills eventually compensate for the upfront cost. A loan can therefore provide the needed capital for installation costs, which can be paid back regularly over several years. WWF currently has some internal loan programmes, which it is looking to expand. Such funding could significantly expand financing options beyond grant funding.

Project funding: Solar power is a practical tool to help a project reach their objectives, whether that be protected area management, biodiversity research, community engagement, etc. As an enabler of on-the-ground impact, solar may have a place in donor-allocated funds for designated projects. While this funding type tends to be the most restrictive, compared to methods listed above that are more internally regulated, many programmes in WWF and outside are funded this way.



PLANNING YOUR SYSTEM

Assessing Electricity Demand

A properly designed system can meet most of the station's day-to-day electricity needs, from lighting and communications equipment to kitchen appliances or even transportation. Estimating the energy demand of your ranger station is a crucial first step for planning your system. The amount of energy you need will ultimately affect the size of your solar array, battery inverter and battery.

To assess your energy and power needs, list the electricity consuming devices you will need and the amount of hours you will use them per day. If you've had electricity at this station before, then your generator's fuel consumption or maximum power output will be an important reference value. If there is an electricity grid, the metered electricity and main circuit breaker size can also inform your calculations.

Below is a simplified example of energy consumption from a real medium-sized ranger station in Cambodia with 10 active rangers. With the basic equipment listed below, electric demand totaled 4230 watts, or about 4.2 kilowatts. These needs were fulfilled by a 6.8kWp array capacity, a 7kW battery inverter and 20kWh of lithium-ion battery. Alternatively, a 35kWh lead-acid battery would also be suitable for this system.[1]

Sample Electricity Demand Assessment

Appliance	Quantity	Power/Item (W)	Power Needed (W)
Laptop	3	50	150
Camera	3	30	90
Walkie talkie	7	10	70
Satellite Internet	1	150	150
Standing fan	5	55	275
Fridge	1	100	100
Rice cooker	1	1000	1000
Water pump (1.5 HP)	1	1120	1120
Projector (LCD)	1	300	300
Mobile phone	5	15	75
Drone	1	150	150
Printer	1	600	600
Lamp	10	15	150
		Total Power Demand:	**4230W**

Energy consumption of appliances can vary widely – we suggest overestimating to avoid running short on energy later!

[1] *The lifetime of lead-acid batteries is greatly affected by battery discharge level, so keeping them charged above 50% is important for their long-term health. That's why you'll need a bigger size than a lithium-ion battery, which can remain at 10-15% charge without major impacts. Read more about batteries in Designing Your Installation.*

Watch the Weather!

The amount of power generated by a solar system depends on several factors, including climate conditions and the size of the system. The example above is in a tropical environment with regular sunshine throughout the year, as well as a rainy season.

Ranger stations in less sunny areas will need a larger solar array (perhaps up to 10 kWp) to ride through the winter months with less sunshine. You'll also need a larger battery to compensate for days without sun (i.e. two or three days of battery autonomy instead of one).

Learn more in the "Designing Your Installation" Section.

While planning your solar system, keep in mind that energy demand is likely to grow over time with increasing operational and living needs. Future system upgrades, such as adding more solar panels or batteries, should be considered during your initial design. Ensure that your key components, like the charge controller, inverter and distribution components, are capable of supporting future expansion.

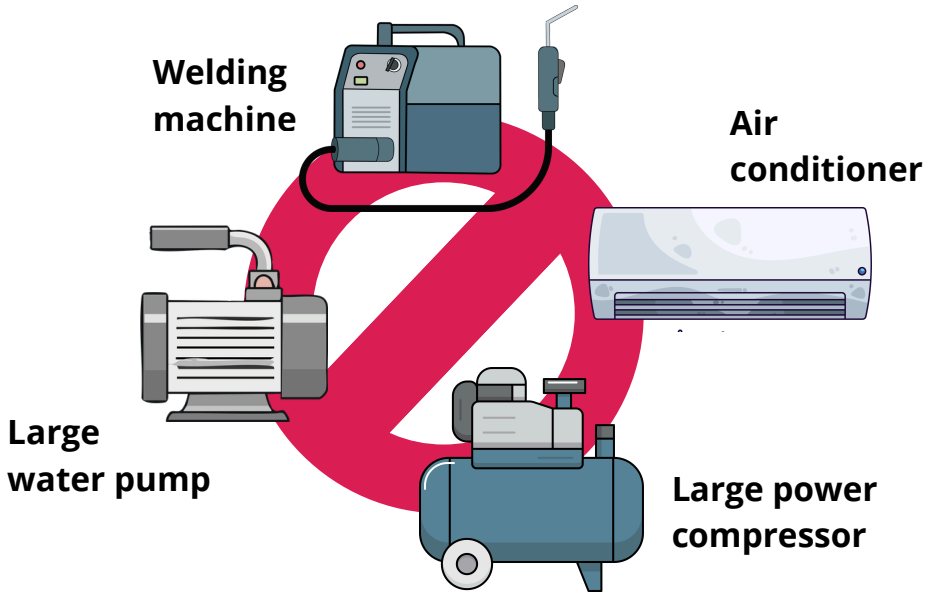
Tips on Appliances and Energy Efficiency

While solar PV is a reliable energy source, it does have limits. On medium-sized ranger stations, a solar PV system would struggle to power large, energy-hungry equipment like air conditioners or welding machines. Installing air conditioning in ranger stations is rarely a good idea, as the large increase needed in your solar array, inverter and battery would make the installation far too expensive. We would say: "If you can, use a fan!"

Using energy-efficient appliances and practices is essential for reducing electricity demand, which keeps your system running smoothly and lowers costs. With a limited energy supply, reducing energy waste where possible will save bandwidth for other uses. Very often, buying energy-efficient appliances is cheaper than buying more solar panels or bigger batteries! You may also consider appliances powered by DC electricity – which are more efficient without requiring an inverter – but they may be more expensive and difficult to find in local markets.

In addition, we recommend charging and using high-power appliances during the daytime hours (9:00 am to 3:00 pm), especially after the sun has recharged your batteries in the morning. This makes use of excess sunshine and avoids draining the batteries at night.

Some appliances are more suitable than others, or should be used differently, for the energy supply that solar can provide. Laundry machines, for instance, should be cold wash only. Some items – like the ones below – we recommend avoiding altogether.



Technical Questions to Ask

Before designing your solar PV system, it's important to understand some key factors about your infrastructure and environment. For instance, if you have well installed electrical circuits from an existing diesel generation-based system, you can save time and cost during the solar installation process. You'll also need to consider site accessibility – for transporting equipment but also for ongoing maintenance and troubleshooting. Finally, national solar PV policies and regulations can influence system size, design flexibility and overall feasibility.

Carefully evaluating these factors will help you create a solar PV system that is affordable, reliable and tailored to your specific needs. Work with your team to consider the questions below:

Does your ranger station currently have electricity? If yes, through a generator?

- Is the electricity distribution (wiring, circuit breakers, etc.) in good shape?
- Is there an earthing system of good quality? [2]

Is there a grid connection available?

- If so, is it single-phase or three-phase? Which voltage? What size is the main circuit breaker between the grid and the building?
- If not, how is the closest grid connection?
- How much does it cost to connect to the grid?

Where could solar panels be installed?

- Is the roof in good shape? Watertight? How big is it? What is the orientation and slope? What type is it (corrugated iron, tiles, flat)?
- Is there shading on the roof from trees, mountains, other buildlings, etc.?
- Is there space for a ground-mount solar installation in case the roof is not a good option?

How accessible is your ranger station for installation, maintenance, etc.?

- How is road access to the location?
- Is there a local solar installer or technician? How far are solar companies located?

What are national solar policies in the country?

- Can you inject surplus power into the grid (if there is a grid)?
- Are there subsidies or other support schemes for this?



[2] *There is no need for a separate earthing system for your solar installation – in fact, it is important that there is only one common earthing system!*

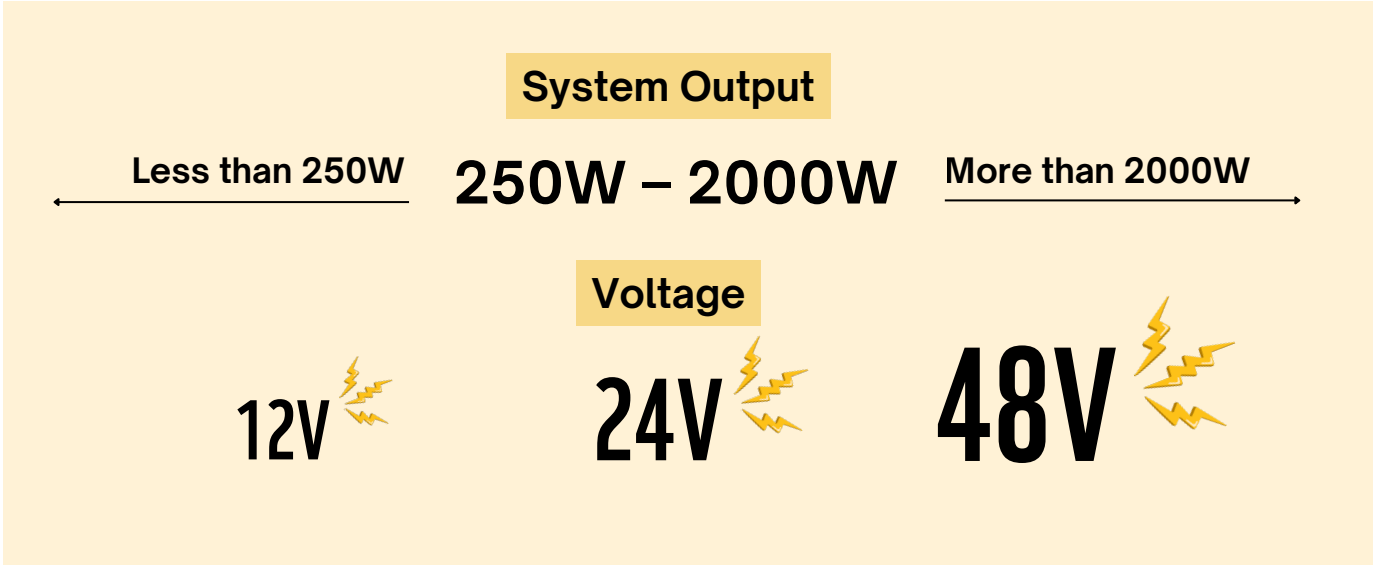
DESIGNING YOUR SYSTEM

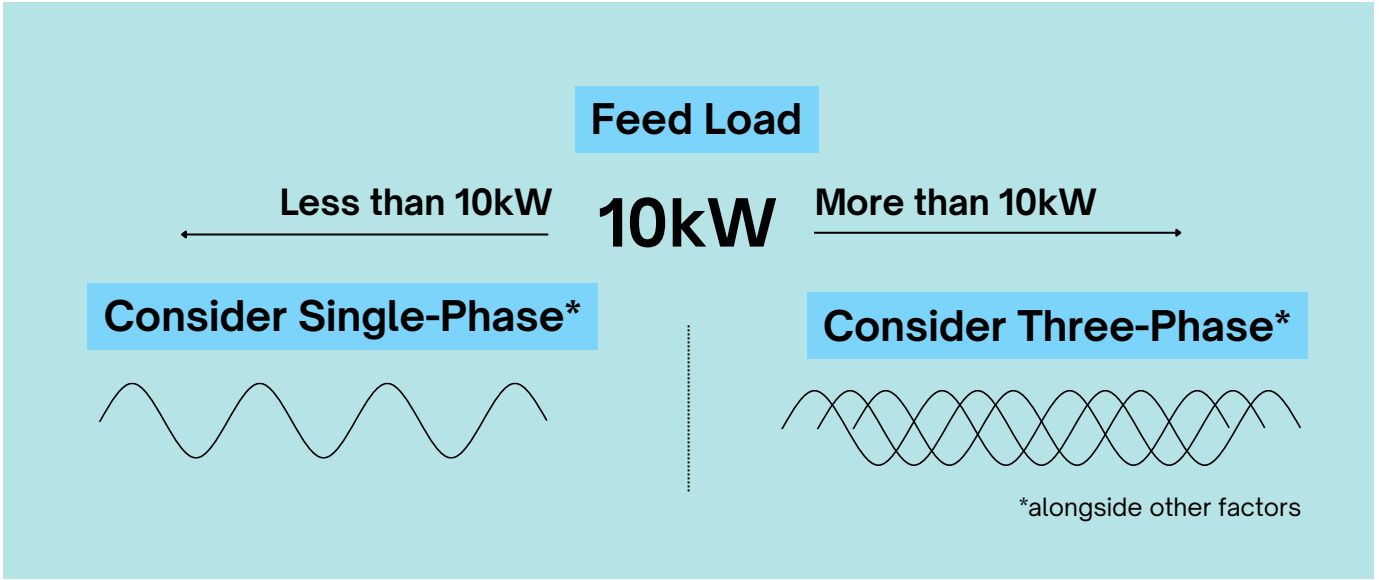
DC Voltage and AC Phases

Your electricity demand assessment, as well as responses to the previous questions set, will shape many of the decisions around your system's design. However, there are a few rules of thumb we follow for most ranger stations.

Firstly, your DC system will need a higher voltage (or greater "electric pressure") the bigger the system output. The average ranger station will likely need a 48V system, with smaller voltages appropriate for systems under 2kW.

On the AC side, you'll need to decide whether a single-phase or three-phase system is required to deliver power to your appliances. Generally, single-phase AC is easier to install and meets requirements for small loads. Local conditions and equipment will influence your choice, but single-phase feed can usually support up to 8–10kW (and sometimes up to 15kW). If your load exceeds 10kW, it's worth considering a three-phase system, which can meet high power demands more efficiently. Sometimes, you will not have a choice: some machinery require a three-phase system to run!





Selecting Your Battery

Choosing the right battery – lithium-ion or lead-acid – is essential for a successful solar PV system. Nowadays, lithium-ion battery technology can offer better value for a similar price to lead-acid batteries. However, they aren't always the right choice.

Lithium-ion batteries have a longer lifespan and are generally more compact and light. They age less rapidly in hot environments, whereas a lead-acid battery lifetime is halved every 10°C or so above 25°C, the standard operating temperature. With quicker charging capabilities, lithium-ion batteries can also accommodate more watts of solar per kilowatt-hour of battery. And, unlike lead-acid batteries, you can add additional lithium-ion batteries to systems over time, as long as they're the same model and within a few years of the original installation.

However, climate and potential tech issues should be taken into account. Most lithium-ion batteries cannot charge if the battery temperature is below 5°C. They also don't thrive in high humidity, and many models are not designed for altitudes above 2000–3000 metres with lower air density. Solutions for heating, insulating or air-conditioning battery rooms are possible, but often prohibitively expensive.

Finally, lithium-ion batteries come with a "battery management system" (BMS), a functioning 'brain' that monitors and protects the battery. This may require an internet connection for firmware updates, and IT issues can occur. Meanwhile, lead-acid batteries are entirely controlled by the battery inverter and charge controller.

So, which to choose? You'll want to consider all these factors together, including your proximity to solar installers, your

	Strengths	Weaknesses
Lithium-ion battery	• Longer lifespan • Faster charging • Compact, lightweight • Supports higher solar array to battery ratio • Can support addition of more batteries	• Not always suitable for cold environments, high humidity or high altitude • Potential for IT issues with battery management system
Lead-acid Battery	• No battery management system (or Internet) required • Can function in cold environments	• Shorter lifespan • Heavier, bulkier • Slower charging • System expansion limited overtime • Ages quickly in hot environment

Battery Blunders!

12V lead-acid batteries should rarely be used, unless for very small solar systems. If you choose lead, choose 2V batteries – and don't put more than three or four batteries in parallel.

Never put lithium-ion batteries in series unless the manufacturer specifically mentions that this is appropriate. For instance, don't put four lithium batteries of 12V in series together to build a 48V system.

proximity to solar installers, your battery room's environmentalconditions, as well as internet monitoring availability. However, lithium-ion battery technology is quickly enhancing, and current limitations may transform in the near future.

Selecting Your Panels

Bigger isn't always better. Many manufacturers have a tendency to produce larger and larger solar panels. While 300W was the typical power output a few years ago, 700W and even 800W panels are now on the market.

While large panels can save money per watt in large, ground-mount projects, we do not necessarily recommend them for ranger stations or rooftop installations. They are typically heavier, making them difficult to carry and challenging to manoeuvre. They'll also need careful consideration when designing the panels' support structure. Larger panels may need stronger support, particularly when there is strong wind or snow in the region. In general, we opt for panels of around 400–450W.

Beware: Altitude and product warranties!

Many solar panels, inverters, charge controllers and batteries do have a maximum operating altitude. If you install them at a higher altitude without manufacturer approval, the warranty is void. Many solar installers do not take this into account!

Adding a Generator

Need to guarantee power access at all times? Consider incorporating a fuel generator into your solar system, which can charge the batteries during the longest bouts of rain or snow. This not only keeps the lights on, but it also protects your battery's long-term health. If battery charge remains consistently low (especially lead-acid batteries), it can result in a shorter lifespan.

From a sustainability perspective, one might be tempted to avoid a generator as a source of carbon emissions. However, occasional use of a generator can prevent the greater environmental impact of premature battery failure, or additional purchases of batteries and equipment.

Generators can also come in handy if you need higher-power appliances for brief periods of time, like a compressor or welding machine. When designing your system, ensure that your generator and battery inverter are compatible. Also, carefully consider what size generator you need to simultaneously charge your battery and supply the loads. We recommend using your generator at approximately 80% of its rated power while charging batteries.


© Bilanol / iStockphoto / Getty Images

Need power on the go?
Portable solar generators are an evolving technology that may be useful for mobile field work. However, these systems may support limited loads or be challenging to fix when problems arise.

INSTALLING YOUR SYSTEM

Call for Proposals and Selecting a Winner

Time to tender out your project! If you're unsure what kinds or sizes of components you'll need, don't worry. In your call for proposals, describe your calculated energy needs based on appliances you'd like to use, and ask the solar companies to make an offer using this information.

We do not recommend a very restrictive call for proposals, where all the required equipment and sizes are detailed like a shopping list. This means that any company, experienced or not, can easily search the prices of equipment and make an offer accordingly. Selecting a winning bidder based on such lists, rather than the quality of designs, is very difficult.

Instead, the call for proposals should be relatively open. Based on the sample electricity assessment from Planning Your System, state the total capacity of the solar array, total battery energy, total battery inverter capacity and quality requirements of certain materials. From there, solar companies must come up with their own design and justify their choices, enabling a more informed selection process. We suggest obtaining at least three offers for a call for proposals.

To select a winner, we recommend scoring the bids based on five factors: price (40%), qualifications and experience (20%), strength of the technical proposal (20%), implementation plan and schedule (15%) and follow-up and maintenance (5%). Using this weighted system, you can assign points out of 100 to rate each proposal. For example, the cheapest proposal will earn 40 points, while another proposal costing twice the price earn only 20 points. points. To assess the qualifications of bidders, consider their years of installation experience, number of projects and the installed capacity of past projects.

SOLAR PROPOSAL SCORING SHEET

CATEGORY	WEIGHT	SCORE
Price	40	20
Qualifications & experience	20	18
Strength of technical proposal	20	16
Implementation plan & schedule	15	15
Follow-up & maintenance	5	4
TOTAL	100	73

Once you've selected a winner, contact them to discuss the final adjustments you would like to make. If you have the technical capacity to check electrical designs, ask for a single line diagram or electrical diagram of the installation. This is a great way to verify a solar company's competence and move forward confidently.

What to Include in Your Contract

Warranties: Include a one-to-two-year warranty on the overall works of the system, making the solar company responsible for the installation's good functioning during this time. The company must also guarantee coverage of labor costs for the first two years of maintenance and troubleshooting work. Beyond that, equipment warranties will remain in effect – but you may need to pay the solar company for their intervention.

Training: Request a training session facilitated by the solar company for the ranger station's local staff. Staff must be able to understand the basic functioning of the system, as well as how to switch the system on or off, read the monitor display and clean the panels. Make sure the company explains which appliances connect to the system and who to contact in case of issues. Additional training on energy efficiency and equipment usage can also help staff understand how to use their limited energy supply wisely.

Online Monitoring: Work with the solar company to connect your solar PV system to the Internet. Nearly all inverter manufacturers provide online monitoring portals – learning more in Maintaining and Monitoring Your Solar Installation.

Disruptive Delays!

After signing your contract, regularly check in with the solar company about the arrival of equipment. Very often, equipment will have to be imported, and with custom checks and boat transport, this can sometimes take more than a year!

Choosing High Quality Equipment

With new solar equipment brands appearing all the time, the solar market has become quite confusing. Some brands are up to three times cheaper than others. When choosing equipment, think about the brand's age, history on the international market, warranty durations, after-sales services quality as well as travel costs for repairs or equipment replacement. Be particularly careful when selecting inverters and batteries – this is where quality and experience of companies can vary most widely.

Before choosing the cheapest option, consider the discomfort or security issues that rangers may face if suddenly deprived of electricity by an equipment breakdown.

If your organization plans to manage several solar plants, we recommend sticking to a few high-quality inverter, charge controller and battery brands. This way, you can maintain stronger relationships with brands for after-sales service and learn how to troubleshoot systems yourself as a first solution. When using a brand's online monitoring portal, it's also convenient to have most of your systems in one place.


© WWF-Bolivia

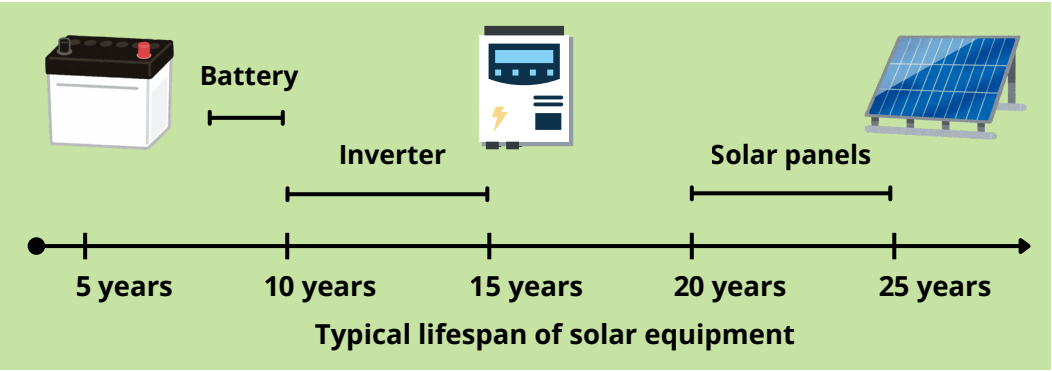
MAINTAINING AND MONITORING YOUR SYSTEM

Planning Ahead

Solar PV is not a "set and forget" solution – it requires long-term planning and regular maintenance for optimal use. For an off-grid system, we suggest getting maintenance by your installer or a technician every six months to one year. For a grid-connected system, every two to three years.[3]

If done properly, a high-quality solar PV system can last 20 or more years. When planning the mid-life of your system, you'll need to carefully consider key components like inverters and batteries. While modern solar panels can typically last 20–25 years, high-quality inverters generally last only 10–15 years. Batteries need replacement even sooner, likely every 8–10 years if the system is well managed. Lithium-ion batteries may last up to a decade, while lead-acid batteries usually have a shorter lifespan depending on local operating conditions. Budgeting in advance to replace components will ensure your ranger station runs smoothly over the years.

Finally, you may consider safeguards against equipment theft, depending on your site's context and risk. Cases of theft are extremely rare in our experience – but can lead to costly disruptions.



Be Repair Ready!

We suggest storing some spare parts on-site, such as fuses, cables, breakers and small components like lugs and screws. When a problem arises, this will speed up troubleshooting and get your solar back on track in no time.

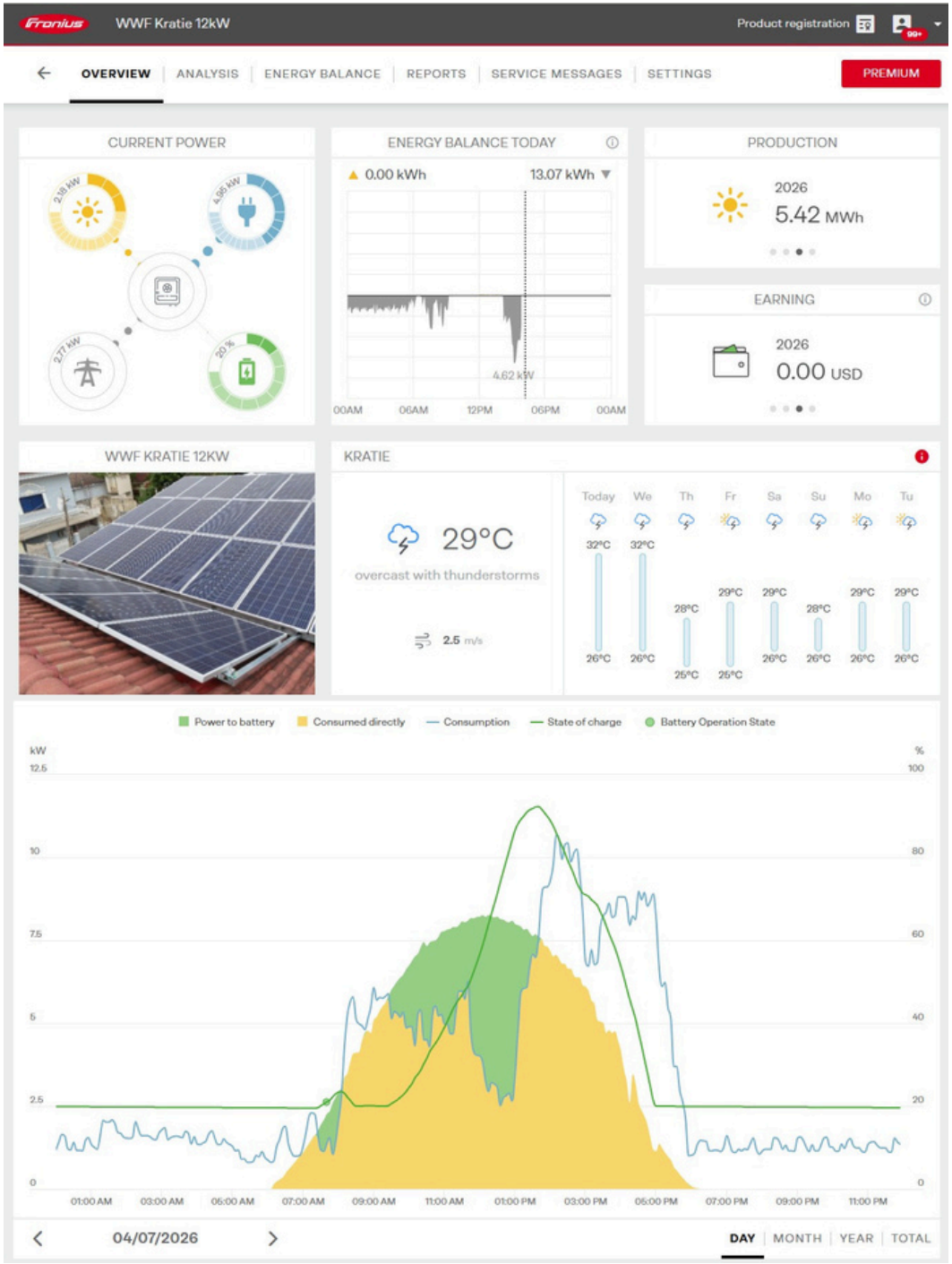
[3] *If the grid is very poor and you have a grid-connected system with battery back-up, you'll need maintenance much more often – perhaps every six months to one year.*

Regular Monitoring and Training

By connecting your solar PV to the Internet, you can virtually monitor your installation from anywhere in the world. Anytime, users can log in to check current energy production, energy consumption, battery charge and even carbon emission savings.

These systems are especially helpful for coordinating a troubleshooting response – team members can remotely identify a drop in productivity and work accordingly with rangers on-the-ground to resolve the problem.

To ensure rangers and local staff are capable of regular monitoring and maintenance, we recommend facilitating regular capacity-building on the ground. Staff turnover at ranger stations is common, and one-time training by the solar company may not be enough. Regular knowledge-sharing with teams on the ground can directly result in better system performance or even a longer lifespan. We often focus training efforts on one point-person, training them based on their pre-existing technical skills.



Example of an online monitoring portal.

Stay Safe, and Keep it Clean

During any maintenance, your safety should always be your number one priority. In addition, keeping your solar PV system clean means keeping your system healthy and running for the long term. Here's a few tips for non-technicians about general maintenance:

Do not touch battery terminals! During system operation, electricity is present in all circuit lines. Even during maintenance, when charge controllers and inverters are switched off, installed batteries still store and supply electricity. Turning off the system does not remove the energy stored in the batteries, so never touch the battery terminals (or any equipment that could be storing energy).

Don't change any settings without professional advice! Your solar system's display screen will show specific parameter settings controlling your inverter, charge controller or batteries. Some settings can be adjusted via the display screen. Never change any settings on the display unless instructed by a qualified technician. Regularly check the display screen for error messages or warning indicators on equipment. Contact your technical staff or installer for assistance when faults or warnings appear.

Check on your SPD! Solar PV systems are equipped with over-voltage protection gear called surge protection devices (SPD), which shield against voltage surges, installed according to local codes and standards. Check the SPD indicator regularly – if it turns red, the device must be replaced. As an extra safety precaution, we recommend switching off the system during lightning or severe storms.

Do not open anything! Unless you are a qualified professional, do not open electrical boxes, remove equipment casings or attempt to modify any PV, AC, or DC wiring. This is extremely dangerous. Always contact a qualified technician for support and only take simple actions (such as turning specific breakers on or off) if you are instructed to do so by a professional.

Keep bugs and dust out! Insects, lizards and other small animals are often attracted to warm areas, and they can more easily enter equipment with a low Ingress Protection (IP) rating. This can cause system problems such as tripped breakers, faults or short circuits. Make sure the area around your equipment is regularly cleaned, keeping dust and critters out!

Regularly rinse your panels with clean water! While exposed to the outdoor elements, dust and dirt will accumulate on the solar panels over time and reduce their performance. We recommend cleaning your solar panels once a month during dry periods (if there is no rain). Do not use detergent or soap – just clean water with a sponge or soft mop will do the trick.

Smile, You're On Camera!

Got a problem? While waiting for a technician, it's always a good idea to take photos or videos documenting the condition of the system. These images might be an important reference point later!

Who's Responsible?

To care for a solar system long-term, we need clear models of ownership and management. Your organization and other involved stakeholders (i.e. rangers, government partners, local communities) should understand and agree who is responsible for day-to-day maintenance and replacing components when needed.

One common model for ranger stations is having rangers directly manage and maintain the system. With rangers living at the location, this option reduces delays and cuts costs of troubleshooting – for example, rangers can carry out instructions from a remote technician if given sufficient training. However, this does not replace the need for regular maintenance by a professional (see Planning Ahead).

Alternatively, system ownership and management can be jointly shared by partner organizations and the government body supervising rangers. In our experience, this set-up works best when solar systems are connected to the Internet and regularly monitored by partner organizations. When issues arise, the partner organization's team can quickly contact the relevant offices, communicate with rangers on the ground or send staff to the location. For government partners with limited capacity, this option can ensure they receive needed support.

Finally, contracting an operation and maintenance (O&M) company to manage the system – usually the original system installer – is another common approach. Often utilized for large scale solar projects, this is an easier solution with a higher guarantee of system performance. However, O&M companies can be very costly, especially in a remote area that's challenging for the solar company to reach.



Solar Stakeholders

- Rangers & government agencies
- NGO or civil society partners
- O&M or solar installer company
- Community beneficiaries

GLOSSARY

Alternating current (AC): Electricity that changes direction many times per second, unlike direct current. This type of power is used in most homes and appliances.

Ampere-hour (Ah): A unit describing a lead-acid battery's capacity, estimating how long it can power a load at a certain current rate (e.g., 100A used for one hour = 100Ah)

Battery management system (BMS): An electronic system that monitors and protects a battery, ensuring it operates safely and efficiently.

Battery inverter: A device that converts stored energy from a battery or solar electricity from a charge controller (DC) into usable household electricity (AC).

Charge Controller: A device that regulates the flow of electricity from solar panels to batteries or battery inverters in order to optimize solar production and prevent overcharging.

Direct current (DC): Electricity that flows in a single direction. This is the type of power generated by solar panels.

Earthing system: A network of conductors connecting parts of an electrical installation to the ground, ensuring safety and operational integrity.

Electrical grid: The network that delivers electricity from power plants to homes and businesses.

Ingress Protection (IP) rating: A rating that shows how well equipment is protected against dust and water.

Inverter charger: A device that both converts battery power (DC) into AC and can charge the battery from an external AC source.

Kilowatt (kW): A "real" unit of power equal to 1,000 watts, used to measure how much electricity a system can produce or use at one time.

Kilowatt-hour (kWh): A unit of energy that shows how much electricity is used or generated over time (e.g., 1kW used for one hour = 1kWh).

Kilowatt-peak (kWp): A measure of the maximum power a solar panel or solar array can produce under ideal conditions.

Lead-acid battery: A battery made of lead and acid that is often heavier and less durable, especially in hot conditions, where its lifespan can shorten quickly.

Lithium-ion battery: A battery with a lithium chemistry that is often lighter, longer-lasting and faster-charging than lead-acid batteries, but not well suited to cold, humid or high-altitude environments.

Load: Any device or appliance that uses electricity, such as lights, fans, or refrigerators.

Operation and maintenance (O&M): The regular activities needed to keep a system running well, including cleaning, checking and repairing equipment.

Photovoltaic effect: The process by which sunlight is converted directly into electricity in solar cells.

Single-phase: A type of electrical power supply commonly used in homes and suitable for smaller loads, as opposed to a three-phase system.

Solar array: A group of solar panels connected together to produce electricity as a single system.

Solar panel: A device made of solar cells that captures sunlight and converts it into electricity.

Solar photovoltaics (PV): Technology that converts sunlight directly into electricity using solar panels.

Surge protection device (SPD): Device that protects electrical systems from sudden spikes in voltage, such as from lightning or power surges.

Three-phase: A type of electrical power supply typically used for larger systems or equipment with higher power needs, unlike a single-phase system.

Voltage (V): The force or pressure that pushes electricity through a wire, measured in volts (V).

Watt (W): The basic unit of “real” power, showing the rate at which electricity is used or produced.



WWF is working in partnership with the Universal Ranger Support Alliance and International Ranger Federation to grow renewable energy access for rangers.

© 2026
© 1986 Panda symbol WWF - World Wide Fund for Nature (Formerly World Wildlife Fund)
® "WWF" is a WWF Registered Trademark. WWF Avenue du Mont-Bland, 1196 Gland, Switzerland. Tel: +41 22 364 9111. Fax: +41 22 364 0332.

For contact details and further information, please visit our international website at www.panda.org