



# **The Solar Energy Handbook:**

**A guide to institutional solar for organizations working in humanitarian settings**

# Introduction *Who is this guide for?*

This handbook is produced as part of a project to scale up the use of renewable energy in humanitarian response by introducing service models that remove the technical and financial risks for organizations. The handbook is produced for organizations that operate in humanitarian areas with limited or no access to grid electricity, and rely on diesel generators to power their operations and facilities.

This guide will help organizations make more informed decisions about how to adopt solar energy by explaining:



Four different options for transitioning to solar energy



Pros, cons and economic analysis for each option



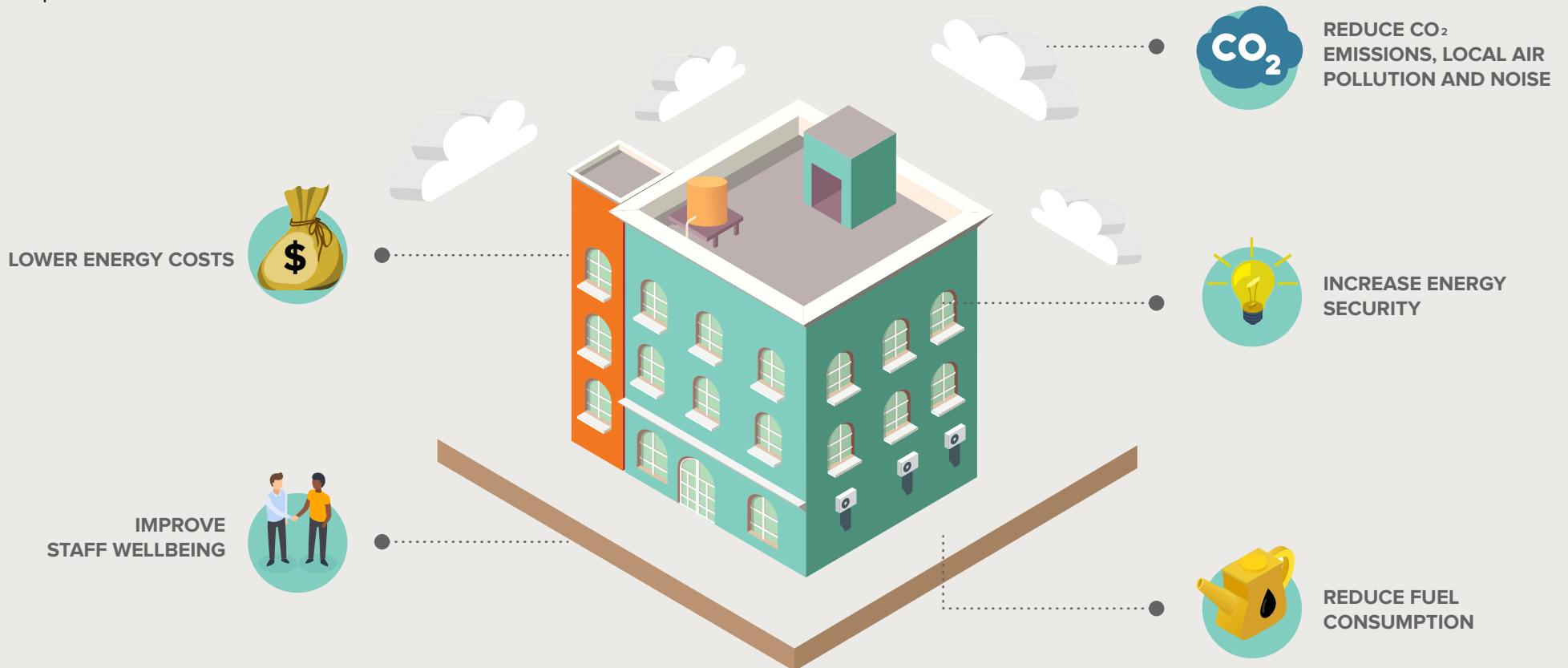
Good practices for organizations starting this journey



# Introduction *Why transition to solar?*

## Organizations operating in humanitarian contexts can expect to benefit from solar energy in several ways

By lowering costs and improving operational efficiency, solar energy can help organizations deliver cost-effective services and improve staff well-being. Cost savings can be invested in providing higher-quality services, and the solar power infrastructure can be extended to local communities to improve their energy access. Solar energy also presents an opportunity for organizations to play an active role in minimizing their environmental footprint and mitigating climate change – one of the key causes of population displacement.



# Context Which technical solution is right for my organization?

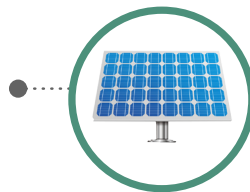
Solar systems can be installed in different configurations based on an organization's energy needs and goals. Most off-grid systems are known as hybrid PV-diesel systems. They include solar PV panels, a diesel generator, inverter and controller, and batteries. Hybrid PV-diesel systems are well suited for humanitarian contexts, as the solar system produces power during the day, and switches over to the generator or batteries when the sun sets. Larger battery banks do increase the cost of the solar system. This guide can help organizations think through which configuration is best for them.

## PURE SOLAR SYSTEM

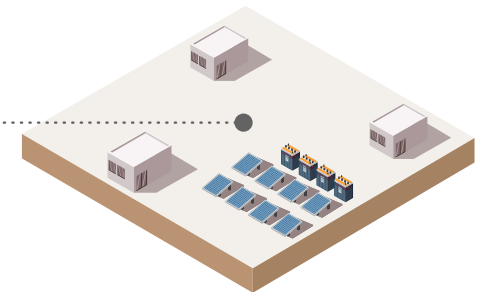
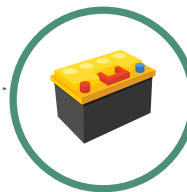
Solar provides 100% of the power; battery bank stores a large amount of power for use during the night and as an emergency back-up.

**Suitable for:** Organizations operating in remote off-grid locations where fuel is very expensive and difficult to procure; organizations whose goal is to go 100% green and secure a cheaper and more reliable source of power; organizations able to make a significant investment and with on-site space for a large solar array and battery bank.

LARGE SOLAR SYSTEM



LARGE BATTERY BANK

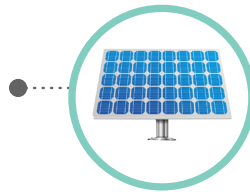


## SOLAR-CONTROLLED SYSTEM

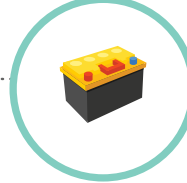
Solar provides 60-90% of the power; generator provides the balance; battery bank stores energy during the day for use during the night.

**Suitable for:** Organizations operating in off-grid locations where fuel is expensive; organizations whose goal is to reduce fuel consumption and improve energy security; organizations able to make a larger investment and with on-site space for a larger solar array.

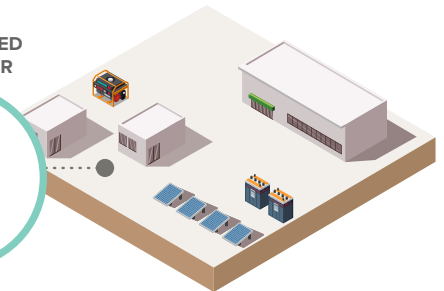
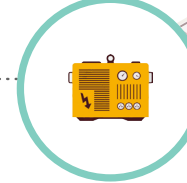
LARGE SOLAR SYSTEM



MEDIUM-SIZED BATTERY BANK



MEDIUM-SIZED GENERATOR

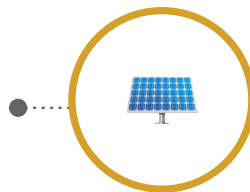


## DIESEL-CONTROLLED SYSTEM

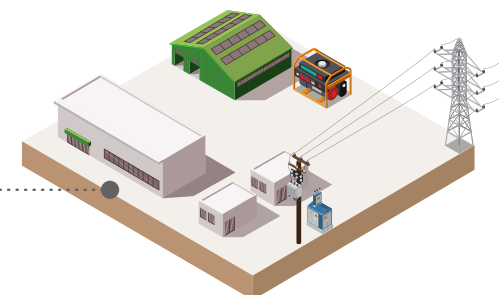
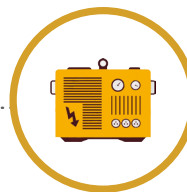
Diesel generator produces 60-90% of the power; solar provides the balance; no batteries.

**Suitable for:** Organizations operating in areas where diesel is available at reasonable prices or where grid electricity is available for parts of the day; organizations whose goal is to reduce fuel consumption and adopt some solar at a minimal investment; organization with limited space for solar panels at their facilities.

SMALL SOLAR SYSTEM



LARGE GENERATOR





# Options *Four pathways to transition to solar*

Organizations transitioning to solar energy should first decide how they want to manage the design, financing, procurement, installation, operations and maintenance of the system. There are four different pathways, or contractual mechanisms, that organizations should consider.

## Purchase

Good option for organizations that prefer to manage their own energy production, have in-house technical expertise, and have access to capital to purchase the equipment. Organization contracts a solar engineering firm to design, procure and install the system. When installed, ownership transfers to the organization, which assumes responsibility for operating and maintaining the system. Organization can outsource the operations and maintenance of the system for a fee.

### Pros

- *Most cost-effective option in the long run (7+ years)*
- *Low monthly energy costs after initial investment*
- *No recurring fees beyond operations and maintenance costs*
- *Ownership of renewable energy asset with 25- to 30-year life span*
- *Capital asset can be depreciated over time*

### Cons

- *High upfront capital cost*
- *Organization takes on financial and technical risk of owning and operating system*
- *Organization owns large renewable energy asset that can't easily be moved*

## Lease to own

Good option for organizations that want to own a solar system, but lack the capital for a purchase. Organization leases system from a solar services company and pays a monthly lease payment. The solar services company finances the design, installation, operations and maintenance of the system. Organization operates its generator and procures fuel. Ownership of the system is transferred to the organization when the lease ends. The organization can outsource the operations and maintenance of the system for a fee after lease ends. Lease agreements normally run for 3 to 10 years.

### Pros

- *No upfront capital cost*
- *No financial or technical risk of owning and operating system during lease*
- *Ownership of renewable energy asset with 25- to 30-year life span after lease ends*
- *Capital asset can be depreciated over time*

### Cons

- *More expensive than purchasing system*
- *Higher monthly fee compared to PPA options*
- *Financial obligation to solar services company during lease*
- *Organization takes on financial and technical risk of owning and operating system after lease ends*
- *Organization owns large capital asset that can't easily be moved*
- *Organization is responsible for operating diesel generator and procuring fuel*

*Note: Ownership risk refers to the financial and technical risks that organizations assume when they purchase a solar system. This includes: need for technically competent staff, risk of purchasing equipment that is not used to capacity, cost of replacing old or damaged equipment, managing demand growth and more. In the PPA options, the solar service company assumes this risk.*

# Options *Four pathways to transition to solar*

There are two types of Power Purchase Agreements (PPA). A limited PPA only covers energy generated by the solar system. A full PPA covers energy generated from a complete energy system, including the solar system and diesel generator. The limited and full PPA's can either have fixed monthly bills or variable monthly bills based on kWh consumption.

## Limited PPA

Good option for organizations that want to transition to solar energy without the hassle of owning and operating their own solar system. Organization signs a limited PPA with a solar services company and buys the solar energy by paying a monthly energy bill. The solar services company will finance the design, installation, operations and maintenance of the solar system. The organization is responsible for operating its generator and procuring fuel. At the end of the agreement, the organization can renew or cancel the agreement, at which time the system will be removed from the facility. Limited PPA's normally run for 3 to 10 years.

### Pros

- *Low upfront capital costs*
- *Lower monthly energy costs compared to diesel*
- *Flexible time commitment with options to cancel or renew agreement*
- *No financial or technical risk of owning and operating system*
- *Organization is not tied to a large capital asset that can't easily be moved*

### Cons

- *More expensive option in the long run (7+ years)*
- *Requires organization to sign a long-term PPA agreement*
- *No ownership of renewable energy asset*
- *Organization is responsible for operating diesel generator and procuring fuel*

## Full PPA

Good option for organizations that want to transition to solar energy and outsource 100% of their energy production. Organization signs a full PPA with a solar services company and buys the solar and diesel generated energy by paying a monthly energy bill. The solar services company will finance the design, installation, operations and maintenance of a complete energy system, including the solar system, generator and fuel procurement. At the end of the agreement, the organization can renew or cancel the agreement, at which time the system will be removed from the facility. Full PPA's normally run for 3 to 10 years.

### Pros

- *Organization fully outsources energy production*
- *Energy production optimized to organization's energy profile*
- *No upfront capital cost*
- *Lower monthly energy costs compared to diesel*
- *Flexible time commitment*
- *No financial or technical risk of owning and operating system*
- *No large, unmovable asset*

### Cons

- *More expensive option in the long run (7+ years)*
- *Requires organizations to sign a long-term PPA agreement*
- *No ownership of renewable energy asset*

# Financial Considerations *What do the numbers look like?*

The economics for each option is different, and each organization should have a clear understanding of how the numbers will impact its finances when evaluating options. This simplified illustrative scenario is designed to help organizations think through the economics of each option. All projects will be different and need to be evaluated on an individual basis.

A United Nations agency is planning to open a new office and guest house in Wau, South Sudan. The agency plans to have 50 staff working in the office during the day and 10 staff living in the guest house. The office and guest house will need electricity 24/7 to operate air-conditioners, office and IT equipment, lighting, electrical fencing and floodlights. Average daily energy use is expected to be 700 kWh.

	<b>Diesel</b>	<b>Purchase</b>	<b>Lease to Own</b>	<b>Limited PPA</b>	<b>Full PPA</b>
	2 x 220-kVA generators operated in 12-hour shifts	Hybrid PV-diesel systems with 100-kWp solar array, 120-kVA generator and 400-kWh battery bank	Hybrid PV-diesel systems with 100-kWp solar array, 120-kVA generator and 400-kWh battery bank	Hybrid PV-diesel systems with 100-kWp solar array, 120-kVA generator and 400-kWh battery bank	Hybrid PV-diesel systems with 100-kWp solar array, 120-kVA generator and 400-kWh battery bank
	Organization purchases generators and fuel	Organization purchases solar system, generator and fuel	Organization purchases generator and fuel	Organization purchases generator and fuel	
<b>Year 1</b>	276,644	603,761	203,548	174,761	143,954
<b>Year 3</b>	156,644	48,761	161,548	132,761	143,954
<b>Year 5</b>	156,644	48,761	161,548	132,761	143,954
<b>Monthly</b>	15,054	13,313	14,112	11,647	12,229
<b>TOTAL</b> <i>Years 1-5</i>	903,218	798,805	842,739	698,805	719,769

Costs in USD



# Financial Considerations *Understanding the numbers*

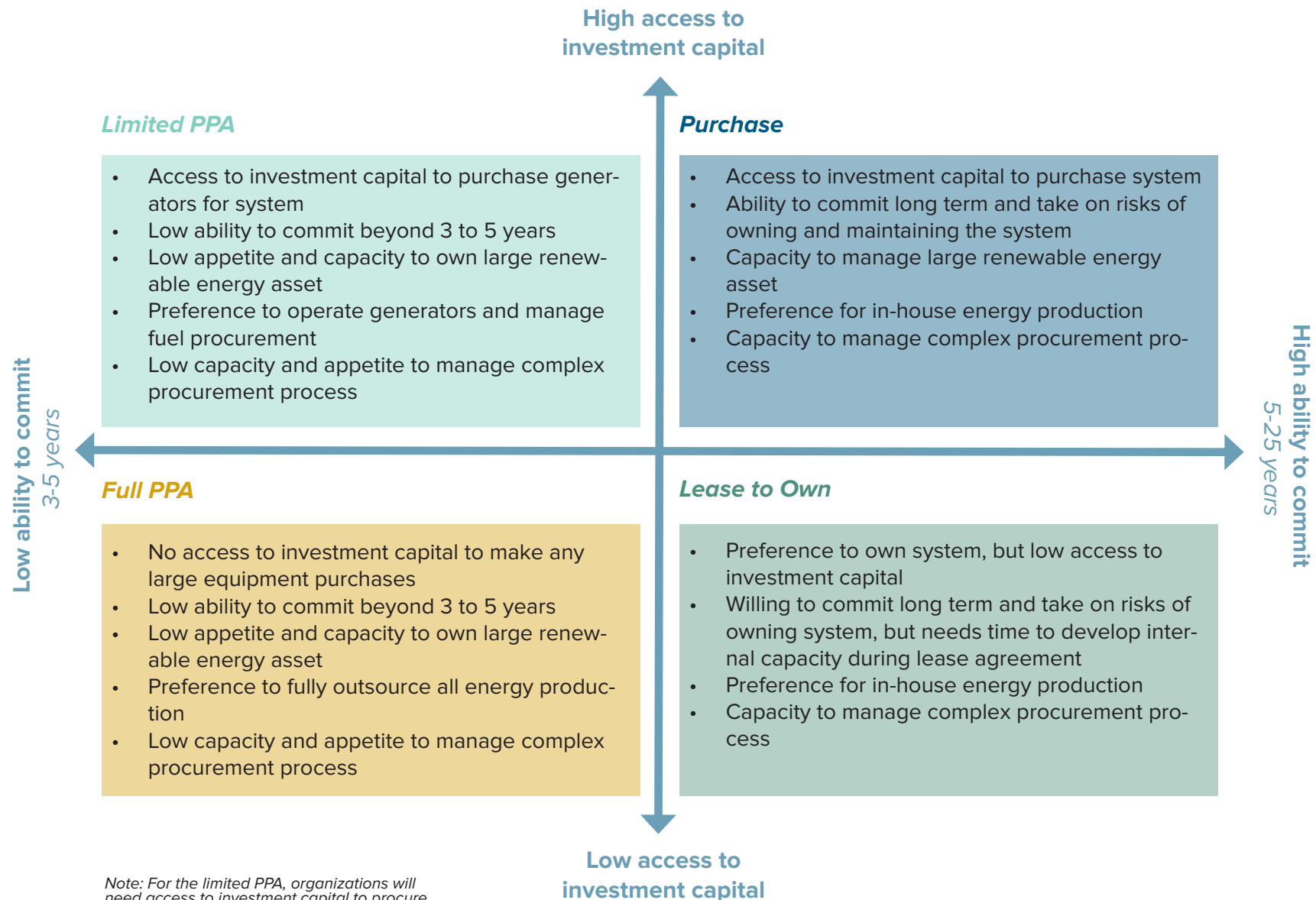
Organizations should have a clear understanding of the fixed upfront capital costs and recurring monthly costs when evaluating the four options. Generators need to be replaced after a certain number of operating hours and batteries need to be replaced after a certain number of charge cycles. Most new Li-ion batteries can last for 5 to 15 years and their replacement costs is not factored into the 5-year analysis in this guide. In the long-run (7+ years) battery replacements become a risk for the purchase and lease to own options while the PPA options become more attractive.

	<b>Purchase</b>	<b>Lease to Own</b>	<b>Limited PPA</b>	<b>Full PPA</b>
<b>Upfront capital costs</b>	Organization pays upfront capital cost of complete system, including the solar system, generators and batteries	Organization pays upfront capital cost of generator	Organization pays upfront capital cost of generator	No upfront capital costs
<b>Monthly energy costs</b>	Operations and maintenance of energy system and fuel for generators	Fixed lease payment and fuel for generator	Fixed or variable monthly energy bill and fuel for generator	Fixed or variable monthly energy bill
<b>Total 5 year energy costs</b>	Upfront capital costs for system, operations and maintenance, and fuel expenses	Upfront capital cost for generator, lease payments and fuel expenses	Upfront capital costs for generator, monthly energy bills and fuel expenses	Monthly energy bills
<b>Notes</b>	Purchasing has very high upfront capital costs, but becomes the more cost-efficient option over longer periods (7+ years)	Monthly energy costs are higher than with Limited and Full PPA options because organization is paying interest charges in the lease payment to finance the purchase of the system	Monthly energy costs are lower than with Full PPA, but organization has to manage the generator and procure its own fuel	Monthly energy costs are slightly higher than with Limited PPA as organization pays a premium for outsourcing 100% of its energy needs

*Note: The size of the solar system is identical in all four options and will generate 75% of the energy from solar. The numbers for all four options are modelled over a 5-year period. Over longer periods, the monthly costs for the lease to own and limited and full PPA's decrease, but the total costs increase. After 10 years, total cost savings increase for the purchase and lease to own options (if the lease has ended).*

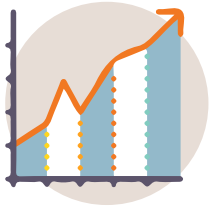
# Decisions *What option is best for my organization?*

Choosing the right option to adopt solar energy will depend on a number of factors, including: organizational objectives on renewable energy, available budget resources, ability to commit and long-term plans for facilities, level of in-house solar engineering skills and more. This tool can help organizations think through which option might work best for them.



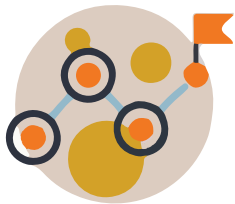
## Practice *What are good practices to employ on your journey?*

The steps involved in transitioning to solar energy will depend on the organization's management and procurement policies, and on the contracting mechanism it chooses. However, there are some common good practices to consider. Organizations should consider engaging a qualified solar consultant or solar consulting firm to guide them along this journey.



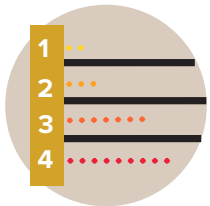
### Conduct an energy assessment

Conduct an energy assessment of your organization to have a clear understanding of your consumption, load profile and costs. A good energy assessment is useful for evaluating your organization's options and developing a good tender document.



### Define your organization's energy objectives

Is your organization trying to reduce energy costs by replacing some of its fuel consumption with a solar system, or is its goal to go 100% green? Having a clear understanding of your organization's energy goal is crucial for designing a solar system that will achieve these objectives. Your organization should also consider implementing other energy efficiency measures to reduce energy consumption.



### Choose the right pathway for adopting solar

Evaluate your organization using the tool on page 8, and think through the pros and cons and economics of each option. Map out qualified solar engineering and solar services companies operating in your area and identify which options they provide.



### Develop a good tender document to guide the procurement process

Clearly define which option your organizations is procuring to ensure that firms can submit appropriate bids. If your organization is purchasing the system, the tender will need to be designed differently than if you are procuring one of the services-based options. A good tender should also be clear about your organizations energy objectives and which type of solar system configuration you are looking for.



### Prioritize regular monitoring and maintenance of the system

If your organization is choosing the purchase or lease to own options, consider contracting a qualified solar engineering firm to provide regular monitoring and maintenance through an Operations & Maintenance (O&M) agreement (after lease ends).



Get in touch to learn more about how your organization can transition to solar power

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