



Facts About Solar Energy

A range of technologies exist to generate electricity on the basis of solar energy. The predominant one used today is photovoltaic (PV) technology. All current Origis Energy solar projects use PV technology.



What is solar energy?

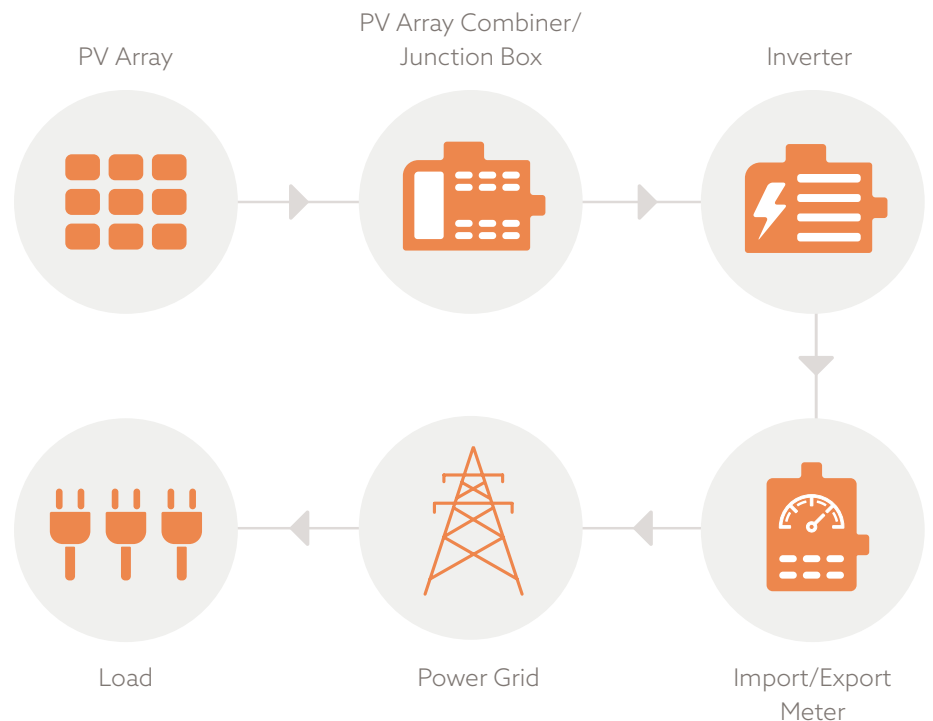
The term photovoltaic is a combination of two words: "photo," meaning light, and "voltaic," meaning electricity. Photovoltaic technology is the term used to describe the hardware that converts solar energy into usable power, which generates electricity from light.

At the heart of PV technology is a semi-conductor material which can be adapted to release electrons, the negatively charged particles that form the basis of electricity. The main semi-conductor material used in photovoltaic cells is silicon, an element most commonly found in sand. There is no limitation to its availability as a raw material as silicon is the second most abundant material in the earth's mass.

All PV cells have two layers of semi-conductors, one positively charged and one negatively charged. When light shines on the semi-conductor, the electric field across the junction between these two layers causes electricity to flow, generating DC (direct current). The greater the intensity of the light, the greater the flow of electricity.

A photovoltaic system therefore does not need bright sunlight in order to operate. It can also generate electricity on cloudy days. Due to the reflection of sunlight, slightly clouded days can even result in higher energy yields than days with a completely cloudless sky.

How does a grid connected photovoltaic system work?



How does a PV system work?

The basis of a photovoltaic system is a set of panels. Different panels are linked in a series called a "string." The current created by the string or a combination of strings is routed to an inverter. An inverter inverts direct current (DC) into alternating current (AC). The AC current is metered and up-scaled to the voltage required for direct use on the premises or to be fed into the public grid.

The main characteristics of a PV system

The electricity produced by a photovoltaic system is dependent on its size, location and the quality of materials and installation. The output of a photovoltaic system in the short run depends on the weather conditions with direct sunlight being the main driver but temperature also has an impact (the hotter, the lower the production). Hence, predictability in the short run (daily basis) is low, except in regions with a very stable climate and predictable weather conditions. In the longer run, e.g. on a yearly basis, the output of a photovoltaic system is much more predictable. The variation in sunlight on a yearly basis is limited to about 5%.

A photovoltaic system requires low maintenance: periodic checkup and cleaning and incident intervention. Over time, the system is likely to be subject to a slight degradation of its performance. The panels usually come with a performance guarantee of 80% over 25 years. As a result of the above, the long term electricity produced by a photovoltaic system is highly predictable.

A photovoltaic system is not harmful to its environment since it doesn't create noise, smell or pollution in any way.

How does a PV project make a positive contribution to the environment?

The production of electricity on the basis of PV-technology does not create any CO₂-emissions. As the PV industry is a new industry with recently installed and efficient manufacturing processes, the CO₂ created during the production is limited.

The electricity produced by the PV project replaces electricity otherwise produced by nuclear or gas or coal fired plants. Depending on the location of the project a PV system will reduce annual CO₂ emissions between 600 tons and 1,400 tons per MWp installed, or the equivalent of 450 cars (driving an average annually of 15,000 km or some 9,000 miles).

Attractiveness of a PV project as a financial investment

Spurred by the threat of global warming and in order to reduce their dependence on nuclear power or fossil fuels, different countries have put in place incentive mechanisms to support the investment in PV projects. These incentives vary from country to country but most EU countries provide for a guaranteed price and off-take for the electricity produced by a PV system for a certain period of time, mostly 20 years. In the US, the incentives are more tax driven and require utilities to have a minimum volume of renewable energy in their production mix. The combination of such incentive programs with the operational characteristics of a PV system provide an excellent investment opportunity. Once the project is operational and enjoys the guaranteed off-take at the agreed price, the cash flow characteristics and hence the risk-reward relationship falls somewhere in between that of an investment in high quality real estate and an investment grade bond.

The climate and solar

There are many ways solar energy generation contributes to a healthy environment.

The most important offset, key to all climate and clean energy initiatives, is the avoidance of further carbon dioxide (CO₂) emissions, the most important greenhouse gas (GHG) pollutant.

Some of the most well-run and efficient companies are turning to solar energy to reduce their carbon footprint and hedge against risks associated with energy prices and climate change.

Origis has a decade plus track record fulfilling Environment, Social and Governance (ESG) initiatives in concert with our solar and energy storage projects. The company's standard and best practices meet and exceed industry guidance and have done so with the leadership of our experienced team for many years.

To learn more about our impact visit:

www.origisenergy.com/our-projects-impact/



Facts About Energy Storage

A range of energy storage technologies are available today. They are designed to save previously generated energy and deploy or use it at a later time. The predominant technology for energy storage employed by utilities and corporations is lithium-ion batteries.



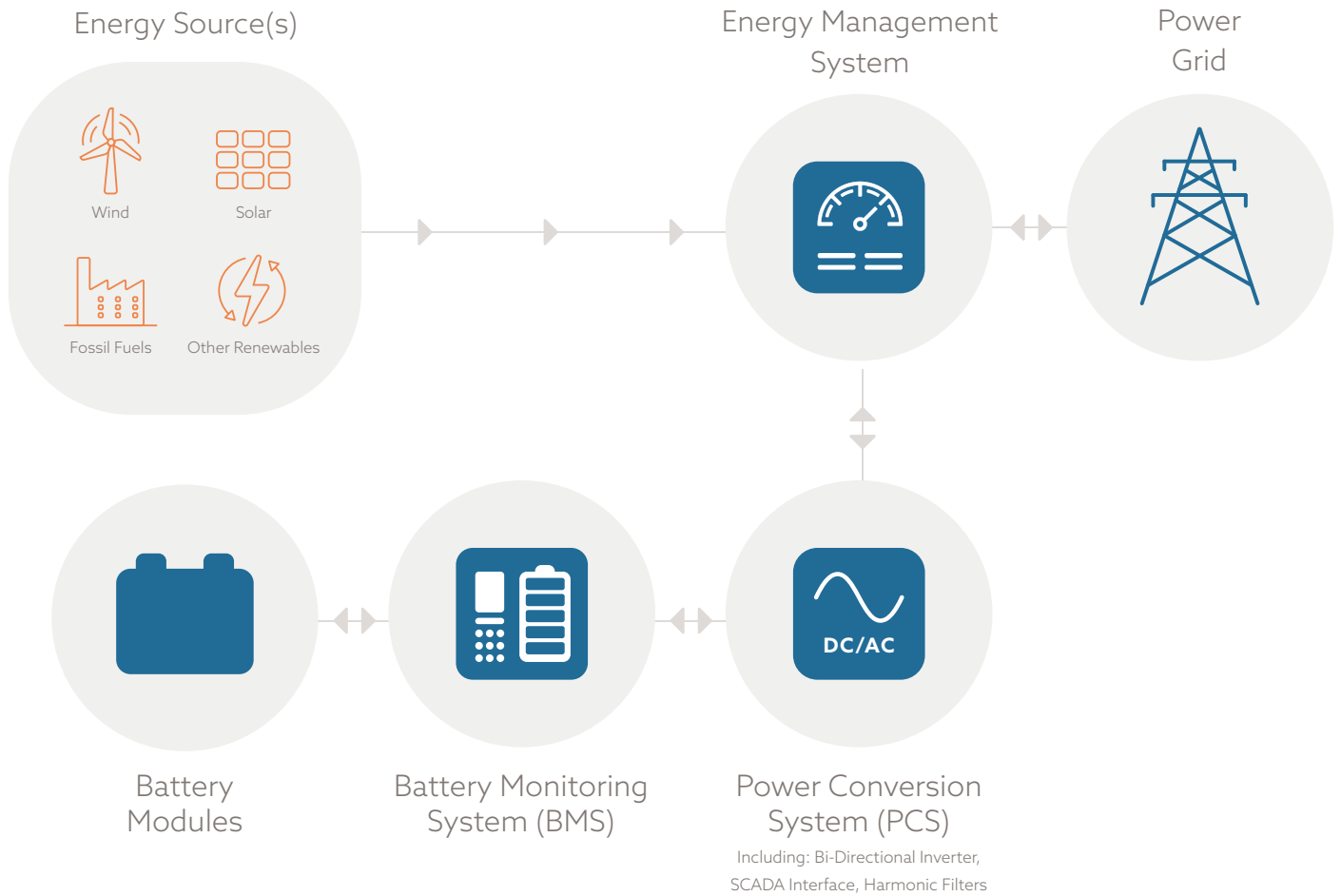
What is energy storage?

"In simple terms, energy storage provides a way to save previously generated energy and use it at a later time. That energy can be stored as potential, kinetic, chemical, or thermal energy and then can be released in various forms, most commonly as electricity. The ability to bank energy for later use makes energy storage a useful and versatile resource for electric companies and their customers."
– Source EEI, Edison Electric Institute, "Harnessing the Potential of Energy Storage" May 2017

Battery and energy storage components are an important part of DER's (Distributed Energy Resources) to build systems moving energy generation and storage closer to energy consumption.

For our purposes here, we are using energy storage as it refers to lithium-ion battery technology.

How energy storage works



What are the components of an energy storage system?

An energy storage system utilizing battery technology is generally composed of the following components:

- Batteries including the racking and battery management system
- The Power Conversion System (PCS) including inverters and transformers
- The Contractor / Integrator who provides software and the building/containers to house the system
- The Balance of System (BOS) including civil works, permitting, etc.

How does lithium-ion battery technology work?

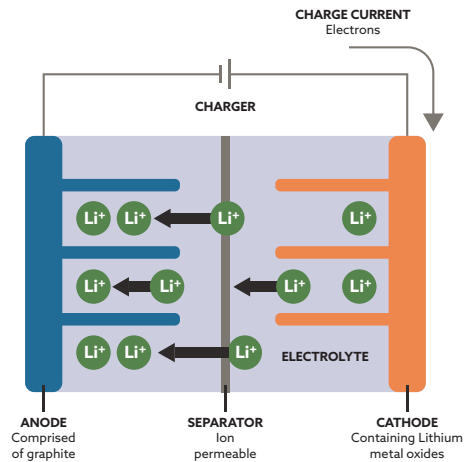
Lithium-ion or li-ion battery (abbreviated as LIB) batteries are found in many modern-day devices including smart phones. The price of LIB technology has fallen dramatically in the last few years as they are used in electronics, electric vehicles, industrial applications and on the electric grid.

Lithium-ion batteries are rechargeable. When the battery is connected to a charger, the lithium ions move in the opposite direction as before. As they move from the cathode to the anode, the battery is restored for another use. Even in the case of large utility-scale installations, lithium-ion batteries are rechargeable. A typical use would be for renewable energy sources like wind and solar to charge the batteries for use at another time. Electricity discharged from the lithium-ion battery is converted from DC power to AC power via a bidirectional inverter.

Lithium ion battery operation

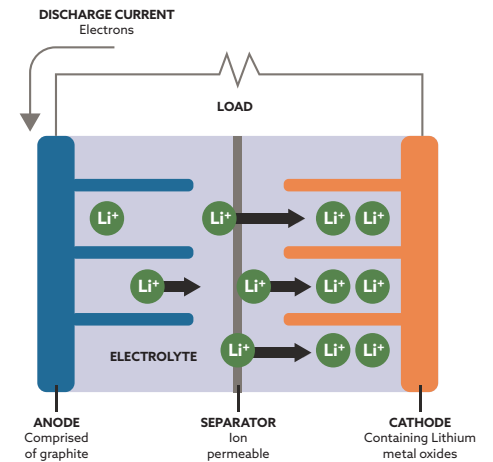
CHARGE

Lithium ions migrate towards the negative electrode, storing electrons from an external energy source



DISCHARGE

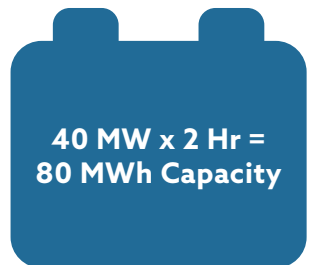
Lithium loses electrons in the negative electrode, driving an external load



What is typical battery capacity?

Battery capacity is generally communicated as stored energy in MWh (Megawatt hours).

For example, a battery that could deliver 40 MW with 2 hour discharge would have capacity of 80 MWh. Alternatively, this same system could discharge approximately 80 MW in one hour.



Attractiveness of a battery storage project as a financial investment

Utility-scale and large corporate purchase of clean energy through power purchase agreements (PPAs) provide stable energy costs, renewable offsets and a host of other benefits to these oftakers.

"Use of storage, particularly batteries, is growing at a rapid rate, with an estimated 260 megawatts (MW) installed in 2016 alone, up 300 percent from 2014. 1) Of the more than 24 gigawatts (GW) of operational storage in the United States, including pumped hydropower, electric companies are the largest users and operators—representing more than 98 percent of active energy storage projects. 2) They are using storage for a wide range of purposes that result in improved operation of the energy grid; increased reliability, resiliency, and operational flexibility; and the integration of more solar and wind power. While installed costs are still relatively high for many energy storage systems, costs are rapidly coming down for some storage technologies." - Source EEl, Edison Electric Institute, "Harnessing the Potential of Energy Storage" May 2017

As the regulatory and policy environment expands support of energy storage systems for use by utility and corporate users, more systems will come online. When combined with solar, the systems represent a rapidly expanding opportunity for the investment community.

How does an energy storage project make a positive contribution to the environment?

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