



***Fact Sheet:  
Photovoltaics and Wind Power***

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## Description

Photovoltaics and wind power will be one important part of the energy mix in the future. The following descriptions will focus on larger scale electricity production. These solutions are not limited to coal intensive regions, these solutions should be implemented countrywide.

### Photovoltaic

Photovoltaic (PV) modules are solid-state devices that convert **sunlight**, the most abundant energy source on the planet, directly into electricity without an intervening heat engine or rotating equipment.

Photovoltaic cells are made of various **semiconductors**, which are materials that are only moderately good conductors of electricity. The materials most commonly used are **silicium (Si)** and compounds of cadmium sulphide (CdS), cuprous sulphide (Cu<sub>2</sub>S), and gallium arsenide (GaAs). These cells are packed into modules that produce a specific voltage and current when illuminated.

PV modules can be connected in series or parallel to produce larger voltages or currents. PV systems rely on sunlight, have no moving parts, are modular to match power requirements on any scale, are reliable, and have a long life. Photovoltaic systems can be used independently or in conjunction with other electrical power sources. Applications powered by PV systems include communications, remote power, remote monitoring, lighting, water pumping, and battery charging. (Kalogirou, 2009)

Photovoltaic systems are used in a wide range of applications and can be designed in a range of configurations, including grid-connected or stand-alone, fixed or tracking, flat plate or concentrator operation. (Pearsall, 2017)

#### Utilization

Photovoltaic systems may be used in a wide variety of applications and configurations, each of which may pose somewhat different risks to different groups of people. In terms of generating capacity, the applications of PV systems may be divided into three general categories:

- **Small scale 5 to 100 kW (peak);** decentralized, onsite application on residential structures ranging from single family dwellings to apartment complexes.
- **Intermediate scale 100 kW to 1 MW (peak);** decentralized, onsite service, commercial or industrial application (hospitals, colleges, shopping centers, office buildings, factories, government buildings, etc.)
- **Large scale 10 MW to 1000+ MW (peak);** central power applications ranging from community scale systems to large scale remote systems.

Small and intermediate scale systems may also vary in the ways in which they are integrated with other energy requirements and interfaced with existing utility services. For example, heat from photovoltaic systems may be collected and **used for space or water heating, storage** systems may be added to provide greater independence from existing grids, or utilities may be relied upon to provide extensive backup. (Neff, 1981)

### Wind power

Wind power is the kinetic energy of wind, harnessed and redirected to perform a task mechanically or to generate electrical power.

Wind is a form of **solar energy**. Winds are caused by the uneven heating of the atmosphere by the sun, the irregularities of the earth's surface, and rotation of the earth. Wind flow patterns are modified by the earth's terrain, bodies of water, and vegetative cover. This wind flow, or motion energy, when "harvested" by modern **wind turbines**, can be used to generate **electricity**. (Wind Energy Development Programmatic EIS, n.d.)

The basic wind turbine design consists of a bladed rotor that drives a shaft to a generator. The generator uses electromagnetic induction to produce a voltage.

Today, small-scale wind turbines for individual use generally have a maximum output of 400-1600 W. In contrast, the largest industrial turbines might generate as much as 7.5 MW. Groupings of turbines are known as wind farms or wind parks. (Rouse, 2013)

In the **United States** there are substantial wind resources in the Great Plains region as well as in some offshore locations.

As of 2018 the largest wind farm in the world was the **Jiuquan Wind Power Base**, an array of more than 7,000 wind turbines in **China's Gansu province** that produces more than 6,000 MW of power. The world's largest offshore wind farm, the **London Array**, spans an area of 122 km<sup>2</sup> (about 47 square miles) in the outer approaches of the Thames estuary and produces up to 630 MW of power. By comparison, a typical new coal-fired generating plant averages about 550 MW. (Selin, 2019)

### Advantages

- Wind energy is a **free, renewable resource**, so no matter how much is used today, there will still be the same supply in the future.
- Wind energy is also a source of **clean, non-polluting**, electricity. Unlike conventional power plants, wind plants emit no air pollutants or greenhouse gases. According to the U.S. Department of Energy, in 1990, California's wind power plants offset the emission of more than 2.5 billion pounds of carbon dioxide, and 15 million pounds of other pollutants that would have otherwise been produced. It would take a forest of 90 million to 175 million trees to provide the same air quality. (Wind Energy Development Programmatic EIS, n.d.)

### Hybrid System

The electricity industry is undergoing transformation at a scale and pace never experienced. Advances in **hybrid energy technology** are expanding the possibilities of electricity generation.

This system is a combination of wind energy and solar energy, used to generate power from each other. Hybrid system is having advantage compared to systems which are totally depend on a single source of energy.

Researchers have a very tough task to maximize the total energy output from the system with **lower cost & reliability**. Generally, wind-solar hybrid power system consists of wind turbines, photovoltaic array, controller and storage battery. Wind turbines are used to convert wind energy into mechanical energy and then into electric energy. Whatever electric energy is generating from this system is alternate & unstable. So some controlling units or inverters are used to make it continuous and store into battery.

This energy utilize for domestic purpose or other. Photovoltaic array having solar panels through series or parallel, converts solar energy into electrical energy. This energy is in DC form, it is stored in battery and controller supply power for AC or DC loads. This system having high daily electricity generation capacity, low fabrication cost, maintenance is low and has other advantages also. (Wagh, 2017)

#### Why using hybrid energy?

A number of trends are driving the shift to hybrid energy, such as record deployment of intermittent renewable **wind and solar PV power resources**. Additionally, industries have seen exponential reductions in the cost of batteries for energy storage, as well as the growth of digital power solutions that enable better integration of generation assets and real-time interaction with the grid. Finally, environmental goals that are being implemented by a wider range of countries, cities, communities, and businesses. (GE power, n.d.)

## Achievements

### Netherlands

Based on renewable energy - wind, sun and batteries - Vattenfall is building its first **full hybrid power plant** in the Netherlands.

The company has now made the investment decision to build an open space photovoltaic system and battery storage facility at its Haringvliet onshore wind project site. The investment volume for the solar system and the storage facility is about 35 million Euro.

The "**Haringvliet Zuid Energy Park**" is the first project in which Vattenfall combines the energy sources wind and sun together with a storage facility. (Vattenfall, 2019)

Further information about the project:

[https://www.sonnenseite.com/de/energie/vattenfall-errichtet-erstes-vollhybrid-kraftwerk-fuer-erneuerbare-energien.html?xing\\_share=news](https://www.sonnenseite.com/de/energie/vattenfall-errichtet-erstes-vollhybrid-kraftwerk-fuer-erneuerbare-energien.html?xing_share=news)

### India

A 41 MW photovoltaic, wind, and battery storage hybrid plant is being built in **Andhra Pradesh**, India. The core components of the project are 25 MW solar PV and 16 MW windpower generation systems, coupled to an optimised energy storage system. (Ross, 2018)

Further information about the project:

<https://www.powerengineeringint.com/renewables/solar/more-solar.html>

## Challenges

### Photovoltaic

The increasing share of renewable energies, especially PV and wind, will require coordinated efforts in order to adapt them to the future **grid infrastructure**. For that, the communication between electronic devices is a key technology.

Although there is an international communication standard with IEC 61850 and the required models for energy systems are already specified, they face an existing heterogeneous system structure in reality. Therefore a migration concept is required in order to integrate today's fragmented devices. Standardised communication and certified products are required to ensure security, safety and reliability in a diversified future grid infrastructure. (Antonello Gaviano, 2012)

### Wind Power

Challenges to the large-scale implementation of wind energy include siting requirements such as **wind availability**, **aesthetic** and **environmental concerns**, and **land availability**.

Wind farms are most cost-effective in areas with consistent strong winds. However, these areas are not necessarily near large population centres. Thus, power lines and other components of electrical distribution systems must have the capacity to transmit this electricity to consumers. In addition, since wind is an intermittent and inconsistent power source, storing power may be necessary.

Public advocacy groups have raised concerns about the potential disruptions that wind farms may have on wildlife and overall aesthetics. Although wind generators have been blamed for injuring and killing birds, experts have shown that modern turbines have a small effect on bird populations.

The National Audubon Society, a large environmental group based in the United States and focused on the conservation of birds and other wildlife, is strongly in favour of wind power, provided that wind farms are appropriately sited to minimize the impacts on migrating bird populations and important wildlife habitat. (Selin, 2019)

## Enabling conditions

### Requirements of wind-solar hybrid power system

To develop this system & to investigate performance, modeling and mathematical calculations have to be done. Different models of hybrid system are covered in literature. Following are the components from review of literature:

- **Meteorological data:** Meteorological analysis of the location has to be made for optimization process. It is important for total utilization of PV/Wind sources. Measuring solar and wind resources data is main input of the hybrid system. That all data should be measured hourly, daily and as per weather or climate change.
- **Load Demand:** It is necessary part of system to design & analyze. To find out the exact load demand it is very complicated and difficult to decide. Load variation for different seasons is not predictable, so system have to design for nearer or more than load demand to full fill requirements.
- **System Configuration:** By studying all data like solar radiation, wind speed and load demand proper selection of equipments have to be made. But sizing of system will be according to the environmental conditions. Because producing power from solar-wind is depend upon the location which is to be selected. (Wagh, 2017)

In general, it is important to start initiatives from bottom up to develop wind park projects. Include inhabitants and local politicians to get more support for the planned project.

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