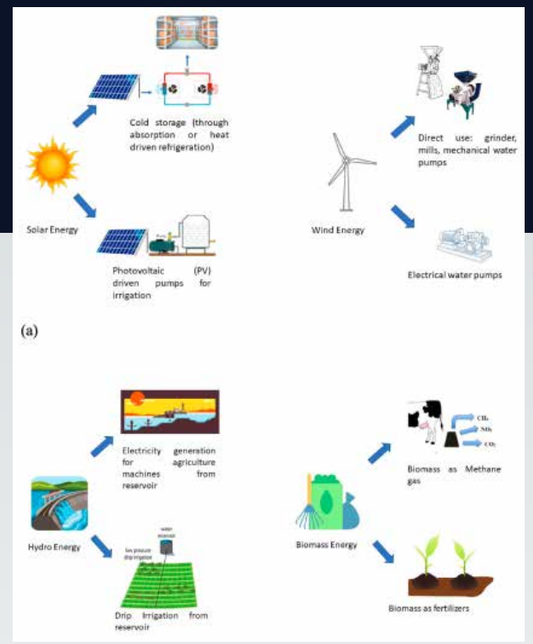
The *Future* is Here

> Sustainable agriculture strives to ensure future food and energy supply while safeguarding natural resources

ABOUT THE AUTHORS

Mr Harsh Vardhan Bhagchandka is President, IPL Biologicals Limited

Dr Vimala Prakash is Head of the Technology and Innovation Centre at IPL Biologicals Limited



Globally, 30% demand for energy is from the agriculture and food sectors. The agriculture production cycle is heavily dependent on fossil fuels from manufacturing fertilizers to running machinery for field operations. Photovoltaic systems being used in residential buildings could be a potential solution to mitigate energy crises for promoting sustainable agriculture. These sources are profusely available in the agriculture sector.

Solar Energy

For example, crops grow in areas where there is sufficient sunlight around the year to support the growth of plants. It means, abundantly available sunlight energy can easily be harnessed using solar panels that can be used to run various agricultural equipment (i.e. water pumps for irrigation). Generated electricity from solar panels can also be used to run various refrigeration and drying units that are commonly used in agriculture to store and increase the shelf life of agricultural produce.

Direct sunlight can also be used for cooking, drying, and water heating using solar cookers, solar dryers, and solar water heaters, respectively. Additionally, fuel cells can enable efficient and effective utilization of hydrogen energy in the agriculture sector because of their flexibility and interoperability

Various applications of renewable energy resources in different agriculture sectors are discussed in Table 1.

Wind Energy

This is another renewable energy resource that can be harnessed by farmers to power their farms. In areas where wind energy is abundantly available farmers can generate electricity using wind turbines. This generated electricity could be used to power heavy machinery involved in agricultural operations and processing of the agricultural produce.

Bio Energy

Another huge source of renewable energy in agriculture is bioenergy source which agriculture has in abundance. According to studies, alone bioenergy can meet around 30%–40% of the entire world's energy needs by 2050. The raw material needed for bioenergy is available in surplus and cheap in the agriculture sector in the form of agriculture, food livestock, and municipal solid waste. Utilization of bio waste in agriculture can help to produce biogas which then can be used for generating electricity. Also, bio waste can be utilized as a fertilizer to reduce the heavy dependence on commercial fertilizers.

Sustainable agriculture strives to ensure future food and energy supply while safeguarding natural resources. The interpretation of sustainability varies by context and country, yielding distinct indicators. Researchers have studied sustainable agriculture for the past 25 years and have developed several indicators. Renewable energy holds a vital role in sustainable agriculture, aiding energy needs and mitigating environmental harm tied to agriculture. It curbs fossil fuel dependency and harnesses agricultural waste for energy. However, a consistent update of renewable energy indicators for agricultural sustainability is needed. Listed below are the few activities where renewable energy source can be used.

Table : 1 Applications of renewable energy resources in different agriculture sectors

Sr. No.	Sector	Renewable energy source	Technology
1	Irrigation	Solar panels assembly	Fuzzy logic and cloud tech
		Solar photovoltaic cells	Pump used for irrigation
		Wind onshore	RO (Reverse Osmosis) of water for irrigation
		PV panels	RO (Reverse Osmosis) of water
		Wind energy	Islanded micro grid for pumps Desalination system
		Geothermal energy	Field irrigation, heat pumps
		Photovoltaic (PV) generator	Ventilation and heating wind turbine
2	Greenhouse management	Photovoltaic and wind	Ventilation and heating Wind-PV hybrid generation system, modelling, simulation and analysis
		PV panels	Photovoltaic greenhouse tunnel
3	Monitoring/ Regulating systems	Solar-powered prototype nodes	Precision agriculture (pa), wireless sensor networks, internet of things (IoT)
		Photovoltaic (PV) centrifugal and positive displacement pump	Humidity sensors and global system for mobile (GSM) module
		Solar panels	Wireless sensor networks
4	Water pumping System	Solar PV water pumping systems	Brushless DC (direct current) motors, centrifugal and positive displacement pump, Solar thermal water-pumping-systems, Vapour power cycles, Wind energy, Wind powered synchronous generators, Biomass water pumping systems, Biomass gasifier dual fuel powered diesel engine coupled with a centrifugal pump
		Hybrid renewal energy water pumping system	The solar wind hybrid system
5	Drying	Solar dryers	Thermal energy storage (TES) Pebble-bed TES
		Solar drying system	Phase change material (PCM) based thermal storage
		Geothermal heating	Heat extraction from geothermal wells Biomass
		Biomass	Hot air is produced from biomass combustion and circulated through the dryer.
		Solar	PCM (pulse-code modulation) integrated heat pump dryers
		Solar thermal energy	Heat pump based solar microwave drying
		Wave and tidal	Reverse osmosis
6	Tractor	Solar radiation	Tractor propelling by energy from solar cells
7	Refrigeration	Photovoltaic panel	Vapour compression cycle
		Solar thermal collector	Steam jet cycle
		Solar energy	Adsorption refrigeration technology
8	Seed sowing	Solar controller	Radio frequency based sowing machine
9	Roasting	Solar	Batch-type direct roasting, Continuous-type thermal-oil based roasting