



Solar PV Powered Cold Storage System

for


Improving Storage Quality and Reducing Wastage of Horticultural Produce

India is the second largest producer of horticultural commodities in the world wherein 88.977 million metric tonnes of fruits and 162.887 million metric tonnes of vegetables were produced during the year 2013–14 (Indian Horticultural database 2014). A large variety of fruits are grown in India, of which mainly banana (33.4%), mango (20.7%), citrus (12.5%), papaya (6.3%), guava (4.1%), grape (2.9%), apple (2.8%), sapota (2.0%), pomegranate (1.5%), litchi (0.7%), etc., are the major ones. Apart from these, fruits like papaya, pomegranate, sapota, jackfruit, and *ber*, in tropical and sub tropical groups and peach, pear, almond, walnut, apricot, and strawberry, in the temperate group are also grown in a sizeable area. A significant portion of perishable produce, such as fruits and vegetables goes waste due to post-harvest losses and poor and inadequate infrastructure for perishable products. The per capita availability of fruits and vegetables is quite low because of post-harvest losses which account for 20–30 per cent of the total production. Besides, a sizeable quantity of produce also deteriorates by the time it reaches the consumer. This is mainly because of the perishable nature of the produce which requires a cold chain arrangement to maintain the quality and extend the shelf-life, if it is not meant for consumption immediately after harvest. Most of the horticultural produce requires a cooling temperature between 0°C and 15°C for safe storage and transient purposes. In the absence of cold storage and related cold chain facilities, the farmers are forced to sell their produce


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SOLAR POWER IS THE ONE OF BEST SOLUTIONS FOR OPERATING SMALL COLD STORAGE SYSTEM IN RURAL AREAS. RUNNING COST OF THE COLD STORAGE SYSTEM CAN ALSO BE REDUCED WITH SOLAR POWER SOURCE. SOLAR ENERGY-BASED REFRIGERATION SYSTEM IS QUITE RELEVANT TO INDIA BECAUSE IT IS BLESSED WITH A GOOD AMOUNT OF SOLAR ENERGY IN MOST PARTS OF THE COUNTRY, THROUGHOUT THE YEAR.



 Picture 1: A view of solar PV panels installed



 Picture 2: Mangoes being loaded in the cold storage chamber

immediately after harvest which results in glut situations and low price realization. Cold chain infrastructure for fruits and vegetables can substantially improve storage quality and reduce wastage. Robust farm-to-retail cold chain solution is required to sustain the growing domestic and export demand. Thus, apart from the large cold storage chambers for long-term storage, cooling system are also required for on-farm or in production catchment for horticultural crops, so that the produce gets cooled in the cold storage room during short-term storage and at the same time, it can be loaded in the transportation vehicle in cool conditions to reduce wastage during transportation.

Energy expenses account for about 28–30 per cent of total expenses in cold storage in India. Hence, electrical energy is a major running cost to maintain the cold storage facility. Moreover, grid power supply in the rural areas is very poor with respect to its quantity and quality. Solar power is the one of best solutions for operating small cold storage system in rural areas. Running cost of the cold storage system can also be reduced with solar power source. Solar energy-based refrigeration system is quite relevant to India because it is blessed with a good amount of solar energy in most parts of the country, throughout the year. The mean annual solar radiation is 4.6–6.6 kWh/m²/day in different parts of India.

Solar PV Powered Cold Storage System

A cold storage facility for storage of fresh horticultural produce (6–8 tonnes), powered by solar photovoltaic with battery backup has been developed at CIAE, Bhopal. The puff insulated walk-in type cold storage chamber (L×B×H, m: 5×4.4×3) was constructed and fitted with a vapour compression refrigeration system (2.5 TR capacity) and a humidifier. Temperature and relative humidity (RH) controllers were fitted in the cold storage chamber to maintain desired room temperature (5–25°C) and relative humidity (65–95 per cent) for storage of horticultural produce. For operation of the cold storage unit, solar photovoltaic (PV) power plant (about 20 kWp SPV panel capacity) and minimum battery backup (240V, 400–450 AH) are required (Picture 1). The battery backup is provided to store solar power generated during the day and supply power during night and cloudy weather. The tubular lead acid solar batteries are used for storage of power off-sun shine operation. Energy output from the solar panel plant would be 70–110 kWh/day which is sufficient to operate the cold storage unit. The power conditioning unit/inverter of the solar power plant converts the DC power produced from the solar panel into three phase AC electricity for operating the cold storage unit and other utilities.

Shelf Life Study of Horticultural Crops in the Solar Powered Cold Storage

The shelf life of the freshly matured unripe mango (*Dashari* varieties) was studied in the month of June by storing the mangoes in the cold storage chamber at 12±1°C temperature and 90±2% relative humidity (Picture 2). Based on the different physico-chemical parameters, it was found that *Dashari* mangoes could be safely stored up to 15 days as compared to 4 days at ambient storage. The total soluble solid (TSS) of *Dashari* mango increased from initial values of 8.8 to 13.0 during the cold storage period. Loss in weight of *Dashari* mangoes was 3.1 per cent in cold storage as compared to 14.5 per cent in case of storage at ambient condition. Firmness of the mangoes decreased from 31.6 kgf to 9.7 kgf. Similarly, the shelf life of the tomato and capsicum increased upto 15 days and 21 days, respectively, in the cold storage as compared to 4–5 days at ambient storage.

Advantages of Solar PV Powered Cold Storage System

The electrical energy required for operating cold storage system (6–8 tonne capacity) is 35–60 kWh/day in different seasons. In solar powered system, the required energy

Table 1: Cost-economics of the solar PV powered cold storage system

Parameters	Details
Assumptions	
Cost of the system	₹2,000,000
Interest on fixed cost, % per annum	12
Working life, year	15
Junk value as @10% of the cost	₹20,000
Material to be handled per year (assuming 1 week storage at full capacity of 6 tonne), tonne/year	282
Cost-economics of the system	
I. Annual fixed cost	
Depreciation	₹120,000
Interest on fixed capital	₹132,000
Sub-total fixed cost, ₹/year	₹252,000
II. Annual variable/running cost	
Annual maintenance cost for battery and other system, ₹/year	55,000
Labour charge, ₹/year (100 man days/year @ ₹200/man day)	20,000
Sub-total variable cost, ₹/year	₹75,000
Total operating cost (I +II), ₹/year	₹327,000
Operating cost for material storage per kg per week including profit @ ₹0.75/kg (considering yearly 282 tonne storage, ₹/kg)	1.90 (1.16+0.75)
Break-even point, tonne/year	153
Pay-back period, years	9.4

for cold storage will be met from solar PV power plant with battery bank and it can be grid independent. Therefore, cost towards grid electrical energy will be saved for operating the system. The solar powered cold storage unit can also be installed in rural and remote areas where there is either no grid supply or erratic power supply.

⚡ Maintenance of the System

The maintenance required for operating the system was quite less. However, the solar panel needs to be cleaned weekly to derive maximum power. Similarly, the battery water level should be checked fortnightly and the water level should be topped up to maintain optimum battery performance. The expected life of the tubular solar batteries is 6–7 years for reputed make, such as Exide and Luminous, etc. The old battery may be replaced with new one after 6–7 years.

⚡ Cost-Economics of Solar PV Powered Cold Storage System

The economics of the solar powered system and saving the grid electricity was worked out. The cost of the solar powered cold storage system (6–8 tonne capacity) with 20 kWp solar power plant and battery backup (240V, 450 AH) will be about ₹20 lakh (with 15 per cent financial assistance on SPV panel from the Ministry of New and Renewable Energy). Expected working life of the whole system was taken as 15 years on the safer side. Replacement of the battery bank after seven years will cost about ₹3.5 lakh (taken as ₹0.50 lakh/year). The solar power would save about 16,500 kWh grid electricity per year, worth ₹115,000/year as running cost of the cold storage. The interest rate on fixed capital is taken as 12 per cent per year. The cost-economics of the solar powered system has been given in Table 1. Operating cost of the stored product in the cold storage was found to be about ₹2.00/kg/week. The payback period of the cold storage system was found to be 10 years. **AU**

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⚡ Solar powered cold storage system

THE ECONOMICS OF THE SOLAR POWERED SYSTEM AND SAVING THE GRID ELECTRICITY WAS WORKED OUT. THE COST OF THE SOLAR POWERED COLD STORAGE SYSTEM (6–8 TONNE CAPACITY) WITH 20 KWP SOLAR POWER PLANT AND BATTERY BACKUP (240 V, 450 AH) WILL BE ABOUT ₹20 LAKH (WITH 15 PER CENT FINANCIAL ASSISTANCE ON SPV PANEL FROM THE MINISTRY OF NEW AND RENEWABLE ENERGY). EXPECTED WORKING LIFE OF THE WHOLE SYSTEM WAS TAKEN AS 15 YEARS ON THE SAFER SIDE.