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Feasibility Study for the Application of Solar Technologies in Dairy Plant

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Abstract- According to the Ministry of new and renewable energy, Government of India, Dairy industry suggested as one of the most suitable industrial area for the commercialization of solar energy. This paper aims to find out the opportunities of solar energy in a dairy processing plant. This study is very important in India, because India is an energy deficient country. Moreover solar technologies are environmental friendly.

Index Terms- feasibility study, solar application, dairy sector in India, solar energy, renewable source

I. INTRODUCTION

This study was conducted at a dairy plant which is located at Kerala state in India. The plant has a capacity of processing about 100000 litres of milk per day. The first step is to identify the energy needs in the dairy plant. Then we study the existing energy sources. After that we suggest a suitable solar technology in place of each energy source. At last conduct a technical economic feasibility study. Also conduct an ecological benefit study. The details are given in the following sections

II. DATA COLLECTION

In a dairy plant energy needs are classified into two- electrical energy needs and thermal energy needs. Electrical energy is used for working of electrical equipments like light, fan, cooling applications ,running of machineries, cold storage, air conditioning, office equipments etc. Electrical energy usage in this plant is about 1.5 lakh units of electricity every month. That means per day usage is about 5000 units of electricity. Electricity supply is from Kerala State Electricity Board.

Heat energy is used for heating processes and cleaning applications. A fire tube horizontal boiler is used here which is the source of heat energy and steam is generated from the boiler. The pressure of the steam is maintained at $5kg/cm^2$and about 4 tonne of wood (as fuel) is used for firing the boiler. The running cost is about Rs 10000 per day and installation cost is about 20 lakh. The heating processes within the plant is identified and listed below

Table 2.1 Heating processes within the plant

NO	PROCESS	TEMPERATURE(˚c)	DURATION
1	Pasteurization phase 1	63	30 min
2	Pasteurization phase 2	72	15 sec
3	Heating for curd	90	30 min
4	Storing for curd	45	4-5 hrs
5	Heating for culture	92	30 min
6	Storing for culture	45	4-5 hrs
7	Heating for Ghee	118	4-6 hrs

III. WORK DONE

3.1 DESIGN OF SOLAR VOLTAIC PANELS FOR ELECTRICAL ENERGY APPLICATIONS

Here we are assuming that depth of discharge of battery, Inverter efficiency and battery Charging and discharging cycle efficiency is about 80%,90% and 80% respectively. Then the combined efficiency of inverter and battery will be calculated as,

Combined efficiency = Inverter efficiency × Battery efficiency= 0.8×0.9=0.72=72%

Battery voltage used for operation = 12 volts

Battery Capacity = 150Ah

Sunlight available in a day = 8 hours/day(equivalent of peak radiation)

Utilization of electricity per month in the production plant = 1.5 lakh units of electricity

PV Panel Power rating = 1KWp

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In operating conditions the actual output power of a PV module is less than the theoretical conditions .Thus a factor called 'Operating Factor' is used to estimate the actual output from a PV Module. The operating factor can vary between 0.60 and 0.90 in normal operating conditions depending upon temperature ,dust on module etc.

A solar PV system design can be done in five steps:

1.Load calculation

Total load connected to PV panel system = 5000KWh/day

2.Estimation of Number of PV Panels.

Actual power output of a PV Panel = Peak power rating × operating factor
= 1×0.75 = .75 kilo watt

The power available for end use = Actual power output of a panel × Combined Efficiency
= .75×0.81 = .6075 kilo watts (VA)

Energy produced by one 1KWp panel in a day = Actual power output × 8 hours/day
= .6075×8= 4.86 kilowatt-hour

Number of PV Panels required = Total watt- hour rating (daily)/Daily Energy produced by a Panel
= 5000/4.86 = 1029 panels

3.Estimation of battery capacity

Total Amp – hour required = Total watt-hour rating/ (Inverter Efficiency × Depth of Discharge × Battery Voltage)
= 5000/(.9×.8×12)=578.7kilo A hr

Number of batteries required = Total amp-hour Rating/ Battery rating under Use
= (578.70×1000)/600
= 965

4.Inverter size calculation

Total Connected load to PV Panel System = 208 kilo watts = 208 VA

Inverter are available with rating of 300KVA

5.Cost analysis of the system

Cost estimation of a solar PV System for Dairy plant is done here. After finding out the required number and capacity of various system components like panels, Battery and Inverter, estimated cost is calculated by adding the cost of all components. But some margin should be taken for other cost like wiring, Supporting infrastructure for panel and batteries, etc.

Cost of solar panels(A) = No of PV Modules × Cost /module
= 1029×200000(Rs.200/Wp)
=RS 205800000/-

Cost of Batteries(B) = No of Batteries ×unit cost
= 965×37500
= Rs.36187500

Cost of Inverter(C) = No. of Inverters ×Unit cost (solectria)
= 1×4237055.9
= Rs.4237055.9

Total equipment cost = A+B+C
= Rs.246224555.9

Additional cost of installation may be taken as 5% of total system Cost**.**

Total Cost of a system = A+B+C+ installation cost
= Rs.246224555.9+12311227.75
=258535782

Operating and maintenance cost of the system =Rs3025/KW/year

(Source: Electric Power Research Institute, "Engineering and Economic Evaluation of Central-Station Solar Photovoltaic Power Plants)

Total running cost year=Rs3112725/year

3.2 AREA REQUIRED FOR INSTALLATION

Area required to install the system= Number of panels(1kw) ×15m^2
=1029×15
=15433m^2

Available roof top area for the installation of pv system=22800m^2

So technically this system is possible in the dairy plant

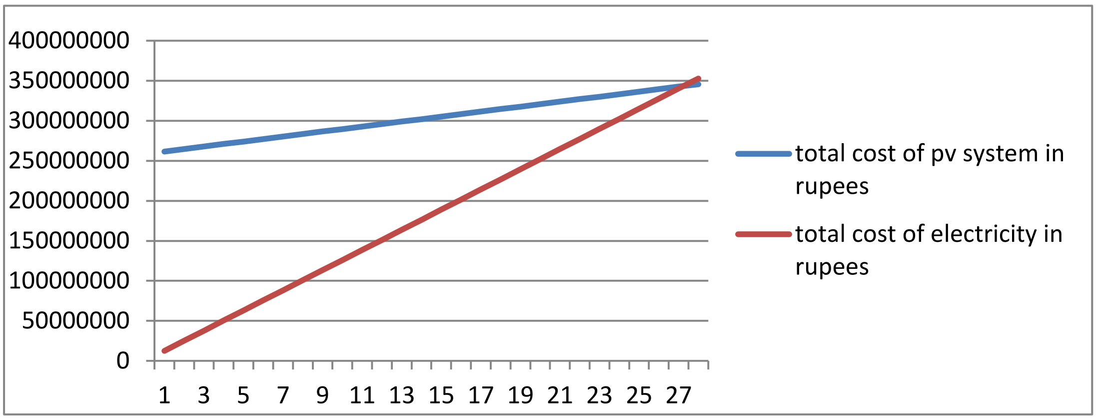
3.3CALCULATION OF PAYBACK PERIOD

Average electricity bill per month=Rs1050000
per year =Rs12600000

Payback period is the time required to return the investment and payback calculation is very important in economical feasibility studies. Here graphical method is used to calculate the solar photovoltaic system. The benefit of using the graphical method is that, it is very easy to understand. If we invest on this system , we can reduce the electricity bill. A graph is plotted between year of return and investment in Indian rupees. The X axis represents year of return and Y axis represents investment in rupees.

By analyzing the graph, we got the payback period as 27 years . But the life cycle of the system is only 25 years. So economically it is not feasible.

Figure3.1. Payback period calculation



3.4 STUDY OF PARABOLIC TROUGH COLLECTORS FOR HEATING APPLICATIONS WITHIN THE PLANT

At present in the plant a horizontal fire tube boiler is used for generating the steam. Instead of this we can use parabolic trough collectors. The preliminary feasibility study is given in the following sections

Heat required to boil 2 tone of water=571200k J
Available time to boil 2 tone of water = 1hour
Average radiation rate in the location = 5 KWh/ m^2
Efficiency of parabolic steam generator= 60%
Available energy per square meter= 2475kJ
Required area =230 m^2
Module width of PTC= 6m
Required module length=38.46m
Available length of a module=13.9
No of module needed=3

3.5 ECONOMICAL FEASIBILITY STUDY

Payback period is the time required to return the investment. payback calculation is very important in economical feasibility studies. Here analytical method is used to calculate the payback period

Expected cost of installation = Rs 18000000 /-
Working hrs / day= 8 hrs
Available sunny days/ year=300 days
Quantity of solid fuel needed for 8 hrs working=1.5 tone
Cost for 1.5 Tons of fuel=Rs 4000
Saving / year=300×4000 =Rs 1200000
Payback period=18000000/1200000
=15 years

The life of the system is ranging from 25 to 30 years. Payback period is only 15 years. Hence it is economically feasible

3.6 ECOLOGICAL BENEFIT

Ecological saving /year=300×4tone wood
=1200 tone wood

It means we can reduce deforestation thereby saving nature and also reduces the emission of carbon dioxide while burning the wood. So this system is very much environmental friendly .

IV. RESULT

The result of this study is summarized below

Table 4.1.summary of result

Type of energy need	Suggested solar technology	Technical feasibility	Economical feasibility	Ecological benefit	Result
Electrical energy	P V modules	feasible	Not feasible	-	Not suggested

needs					
Thermal energy needs	Parabolic trough collectors	feasible	feasible	beneficial	Suggested

V. CONCLUSION

Large quantity of wood is used to produce steam in the plant. According to analysis, parabolic trough system is suitable for heating applications in the plant in sunny days. But there are lot of practical limitations to implement this. Economically this system is not that much profitable. But considering the ecological benefits while using this system instead of fire tube boiler , it is a good option. Ecological impacts like, deforestation, global warming etc can be reduced with the reduction of usage of wood (as fuel) . By considering the importance of green conservation of our planet and scarcity of energy, it can be considered as the future steam boiler for plant.

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