Daffodil International University

Project On

Study of Solar Based Irrigation System in Bangladesh

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A project submitted in partial fulfillment of the requirement for the degree of Bachelor of Science in Electrical & Electronic Engineering

Department of Electrical & Electronic Engineering
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PREFACE

To Be a B.Sc Engineer from Daffodil International University, we have to take a four credit course as EEE-499 (Thesis/ project). For our graduation we took EEE-499 as a project work. This dissertation is based on solar irrigation system.

We perform our project carefully.

The project titled "**Study of Solar based Irrigation System in Bangladesh**" submitted by Md.Rezwanul Haque (103-33-311) and Md.Azizul Hakim (103-33-314) has been accepted as satisfactory in partial fulfillment of the requirements for the Degree of Bachelor of Science in Electrical and Electronic Engineering.

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DECLARATION

It is hereby declared that this project or any part of it has not been submitted elsewhere for the award of any degree or diploma.

Signatures of candidates

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DEDICATION

To our parents

ACKNOWLEDGEMENTS

We are very much grateful to the almighty Allah for the successful completion of the work. We are greatly indebted and respectful to our supervisor **Dr. Md. Fayzur Rahman, Professor and Head** Dept. of Electrical and Electronic Engineering for her great support guidance and encouragement, not only to our research work but also for her diligence and generosity.

We also like to specially thank to our sir professor Dr. M. Shamsul Alam, Dean Faculty of Engineering, a brilliant teacher and excellent human being, who lighted through the course of our graduate work.

We also extent our thanks and gratitude to our professor Dr. Md. Fayzur Rahman, Head Dept. of Electrical and Electronic Engineering and all faculty members and staffs of DIU, who helped us time to time regarding our research work and also in the department to help this make a successful one.

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ABSTRACT

In this thesis we analyzed the possibility of solar based irrigation system in Bangladesh. We developed a dc based system and applied the solar power to a dc motor. A prototype system has been developed. In this prototype system a dc motor has been used as a pump for irrigation purpose. The motor is of 35 watt. Although this motor is of lower rating, but the concept can be used in ac pump operated system fruitfully. If we use inverter at the output of the dc system, we shall get ac output which can be applied to an induction motor based pump system.

Keywords: RETScreen, STW (Shallow Tube Well)

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STW	Shallow tube well
DTW	Deep tube well
LLP	Low Lift Pump
GHG	GreenHouse Gas

CHAPTER 1

INTRODUCTION

1.1 Introduction:

Bangladesh is a agricultural country with its 36 % GDP based on agriculture.64% of employment is due to this reason. The national demand of electricity is 7500 MW but production available is 6350MW. Almost 75% of Bangladesh's 161 million citizens live in rural areas. In 2013 only an estimated 59.6 % of the Bangladesh population is connected to the electricity grid. In 2010, the Bangladesh Bureau of Statistics mentioned 90% access in urban areas and only 42% access in rural areas. The electricity supply is not reliable supply does not meet demand. However, as far as possible, load shedding is scheduled. and only 13.5% (760 MW) is used as irrigational electricity. The need to irrigate agricultural land efficiently , economically and sustainably is critical for food security. Costs for irrigation using diesel power are rising at > 10% per year.

1.2 The irrigation system of Bangladesh:-

Comprises of three types of pumps, namely-

1. Shallow Tube Well (STW)
2. Deep Tube Well (DTW)
3. Low Lift Pump (LLP)

LLP and STW mostly use diesel and DTW is mainly operated by electricity.
A solar powered water pumping system initially costs more than a diesel or electric powered pump but requires far less maintenance and labor. Comparing

installation costs (including labor), fuel costs and maintenance costs over 10-year period, it is observed that solar pump is an alternate choice. Bangladesh situated between 20º34’ and 26º38’ North latitude, 88º01’ and 92 º 41’ East longitudes east, with average solar radiation between 4 and 5 kWh/m2/day, is ideal location for solar energy harvesting.

A brief description of Bangladesh Irrigation System is tabulated in chart

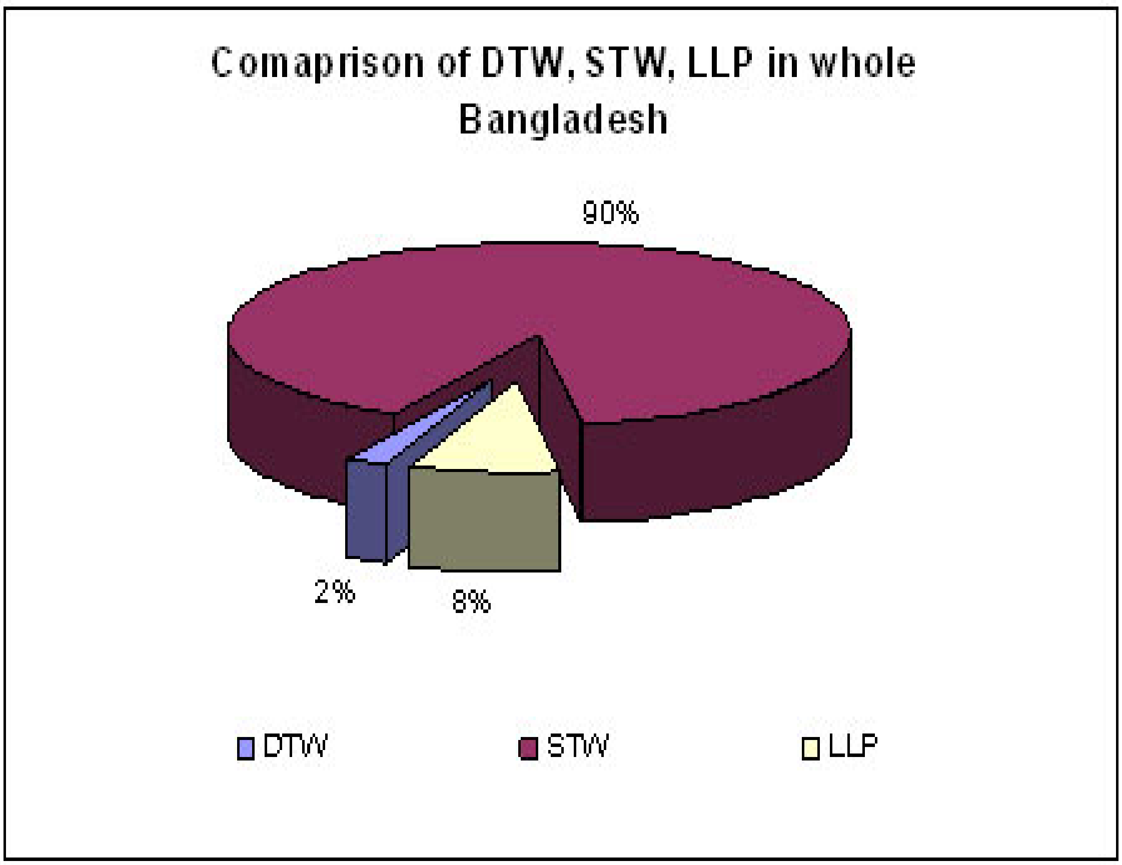
This chart we find from(BADC).

Type of Equipment	Name of Organization	Operated by Electricity					Operated by Disel			Total		
		Unit			Irrigated Area (ha)	No. of Farmer	Unit	Irrigated Area (ha)	No. of Farmer	Unit	Irrigated Area (ha)	No. of Farmer
		PDB	REB	Total								
DTW	BADC	934	9138	10072	258930	790878	1090	21940	51627	11162	278870	842505
	BMDA	929	13115	14044	403832	747644	5	143	425	14049	403975	748069
	OTHERS	749	7547	8296	203016	648854	1815	48481	118323	10111	251407	765177
	TOTAL	2612	29800	32412	863778	2185376	2910	70564	170376	35322	934342	2355751
STW	BADC	11	37	87	150	400	151	355	1065	199	505	1465
	BMDC	0	0	0	0	0	0	0	0	0	0	0
	Others	24636	228789	253425	809715	2906782	1269985	243220	8783883	1523410	3241935	11689865
	Total	24647	228826	253473	809865	2906182	1270136	2432575	8784948	1523609	3242440	11691130
LLP	BADC	106	789	895	35171	82238	4830	50680	120837	5725	85851	203075
	BMDC	11	21	32	805	1086	0	0	0	32	805	1086
	Others	1391	8538	9929	140901	439564	154883	808179	2304278	164812	949080	2743842
	Total	1508	9348	10856	176877	522888	159713	858859	2425115	170669	1035736	2948003
							0					
DTW+STW+LLP		28767	267974	296741	1850520	561446	1432759	3361998	11380439	1729600	5212518	16994884
Manual & Artesian Well		0	0	0	0	0	0	0	0	0	34560	17280
Traditional Method		0	0	0	0	0	0	0	0	0	28320	50152
Gravity Flow		0	0	0	0	0	0	0	0	0	97707	109735
COUNTRY TOTAL		28767	267974	296741	1850520	561446	1432759	3361998	11380439	1729600	5373105	17172051

Table 1.1 (Irrigation system of Bangladesh)

From the above chart it is easily describable that 90 % of the pumps are STW type and this ratio can be shown as-

1.3 Comparison of DTW, STW and LLP in whole Bangladesh:-



The pie chart above distinguishes the methods of irrigation in Bangladesh. The STW leads the table. The coverage of STW and DTW are shown in the next figure1.1, which resembles a Bangladesh map

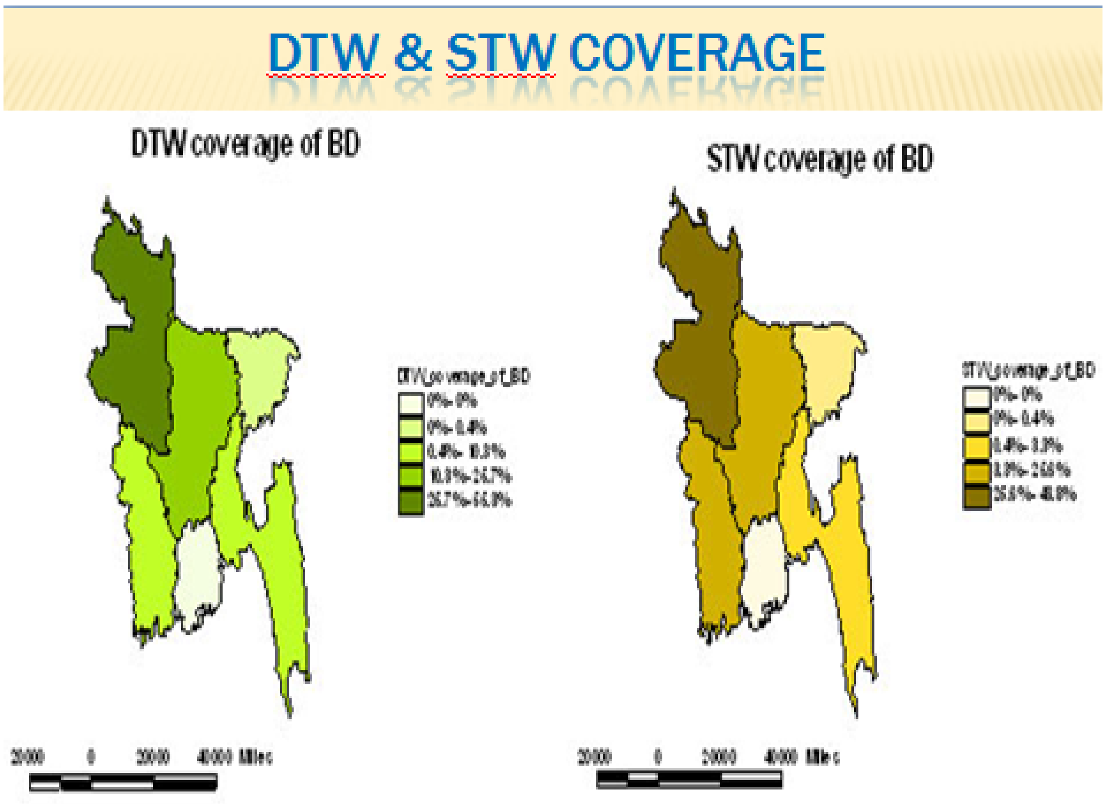


Figure: 1.1(DTW AND STW Coverage)

It is also found that about 90% of these STW are diesel run and this causes the government to use a large portion of its irrigation budget to be spent on subsidy only.

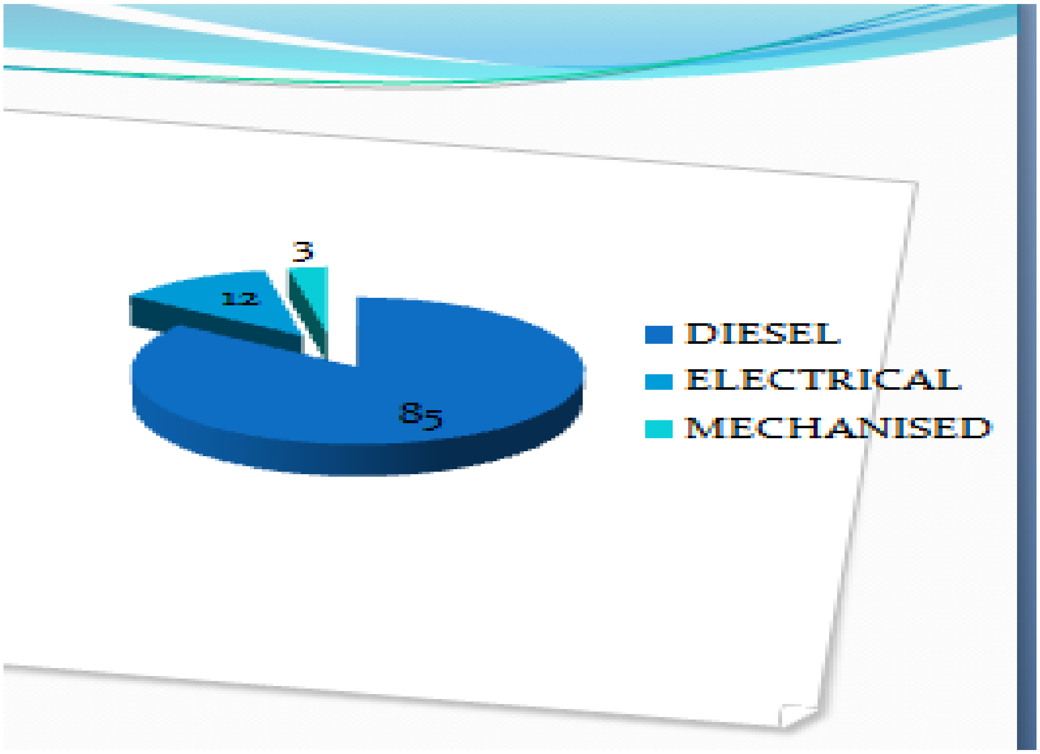


FIG 1.2: PUMP OPERATION

So, our main focus is to replace these STW (90% of pump), with solar irrigation pump and thus to reduce the subsidy and thus ultimately reducing the irrigation Cost of farmer.

1.4 Prospect of solar irrigation in Bangladesh:

Bangladesh is located in the Tropical region bestowed with direct solar insulation .This fact comprises the possibility that solar irrigation system should be practical and feasible in Bangladesh. The NASA provides us with the data below in chart .

Site reference conditions — Select climate data location

Climate data location: Dhāka

Show data: ☑

Month		Air temperature	Relative humidity	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree-days	Cooling degree-days
		°C	%	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January		19.7	53.8%	4.36	100.9	1.9	21.5	0	302
February		23.0	49.2%	4.92	100.7	2.1	25.6	0	364
March		26.5	52.4%	5.59	100.4	2.2	29.3	0	510
April		27.2	69.5%	5.76	100.2	2.5	29.1	0	515
May		27.7	78.0%	5.30	99.9	2.5	29.2	0	547
June		28.0	84.5%	4.53	99.5	2.4	28.7	0	539
July		27.7	86.4%	4.23	99.6	2.2	28.1	0	547
August		27.6	85.7%	4.29	99.7	1.9	28.1	0	546
September		27.0	84.7%	4.02	100.0	1.7	27.5	0	510
October		25.5	80.1%	4.32	100.4	1.5	26.0	0	480
November		22.5	72.8%	4.28	100.8	1.6	22.9	0	375
December		20.2	61.0%	4.21	101.0	1.7	21.1	0	316
Annual		25.2	71.6%	4.65	100.3	2.0	26.4	0	5,551
Measured at	m					10.0	0.0		

NASA UNEP GEF reeep — Complete Energy Model sheet

RETScreen4 2012-06-01 — © Minister of Natural Resources Canada 1997-2012. — NRCan/CanmetENERGY

Table 1.2(Daily Solar Radiation)

This can also be shown as below in figure 1. 3

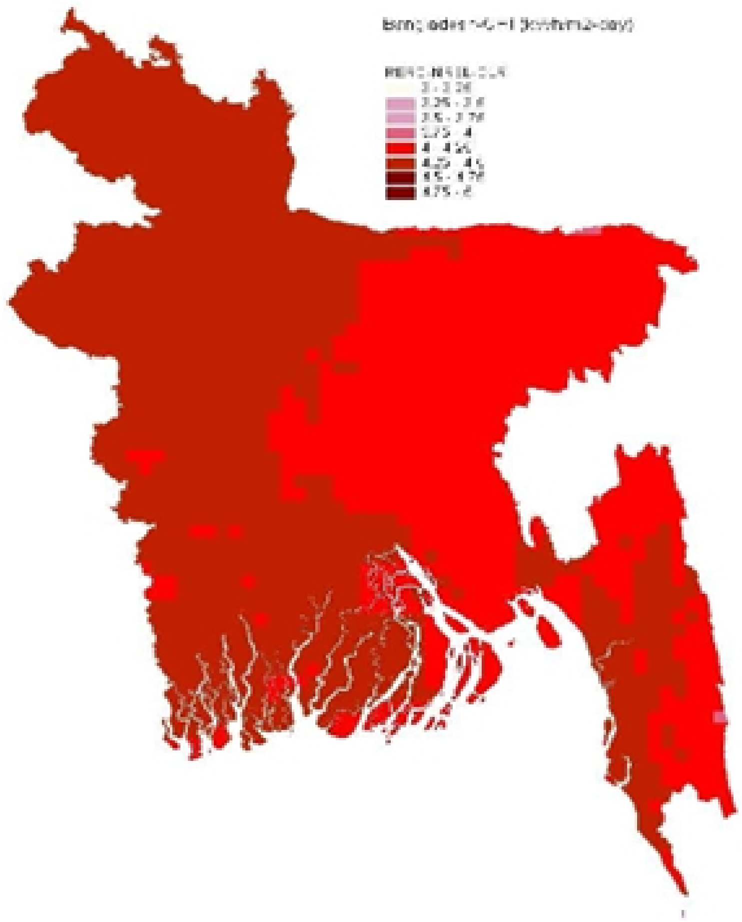
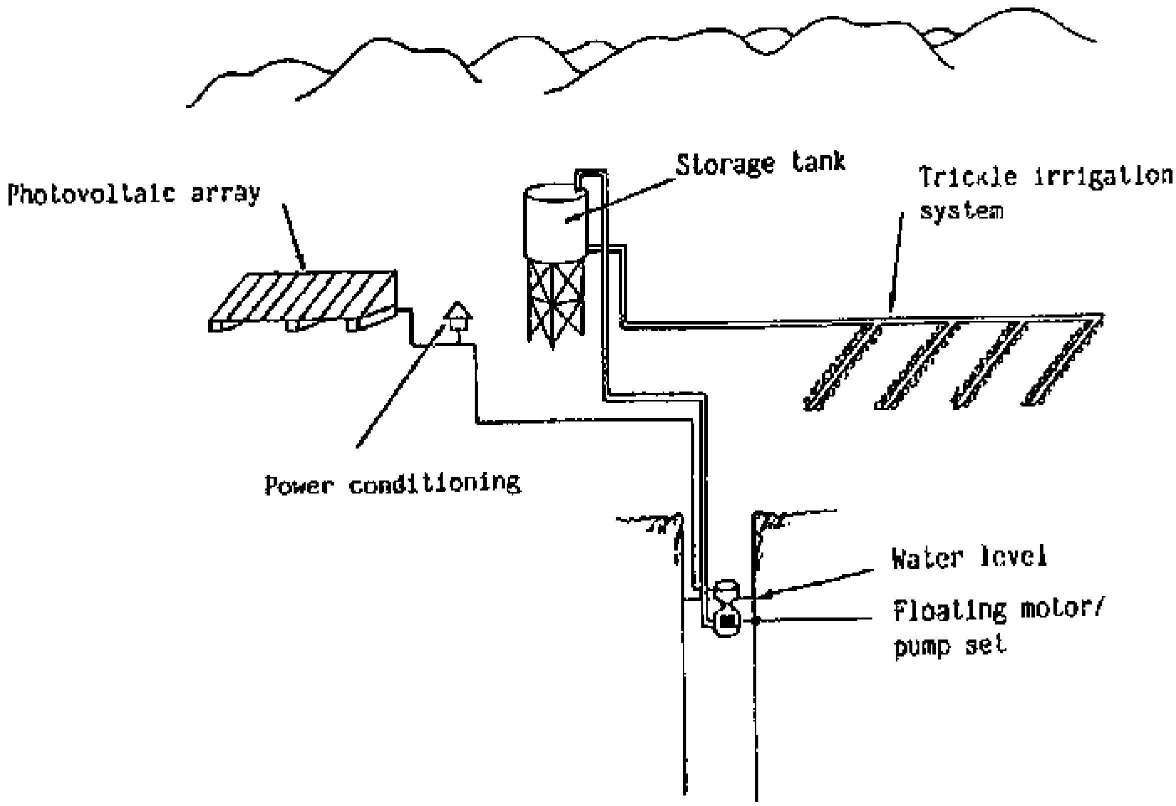


Fig 2: Global Horizontal Irradiance map of Renewable Energy Research Centre (RERC)-National Renewable Energy Laboratory (NREL) - *German* Aerospace Center (*DLR*) showing averaged NREL and DLR maps tuned to Dhaka

Figure: 1.3(Solar Radiation of Bangladesh)

1.5 Proposed irrigation plan



CHAPTER 2

EXPERIMENTAL SETUP AND PRACTICAL DATA

2.1 The Practical Data:

	7am-9am	9am-11am	11am-1pm	1pm-3pm	3pm-4pm	4pm-5pm
Panel Voltage	15.5 v	17.2 v	16.9 v	17.1 v	13.5 v	7.7 v
i/p Current (Battery)	2.72 A	2.91 A	2.84 A	2.90 A	2.42 A	1.42 A
i/p Power	42.16 w	50.1 w	47.9 w	49.5 w	32.67 w	10.9 w
Motor Voltage	10.1 v	11.7 v	11.5 v	11.5 v	9.1 v	5.2 v
Motor Current	3.20 A	3.37 A	3.31 A	3.42 A	2.75 A	2.20 A
Efficiency , η	95.32%	100%	92.11%	97.07%	95.24%	95.45%

Flow rate,Q=1/4 πD^2L*N/2 m^3/min

Here,

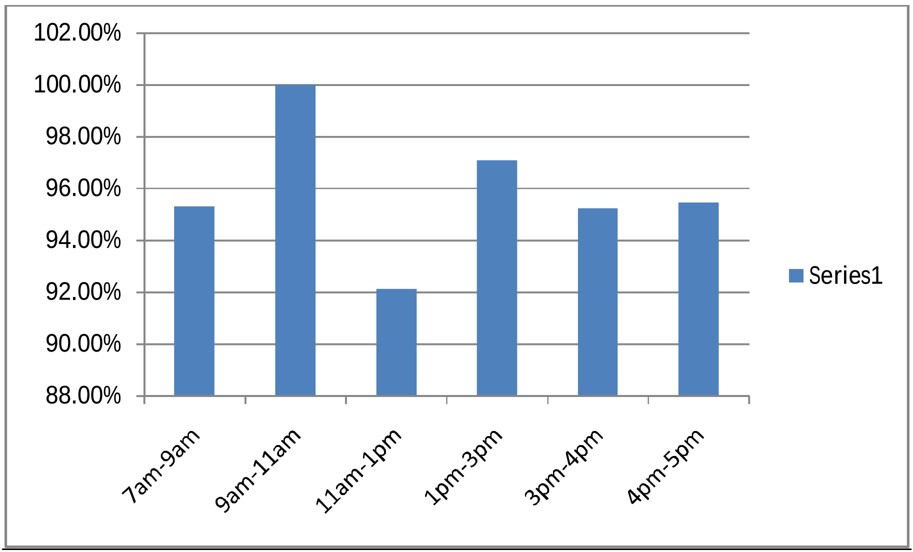
Delivery line distance ,D=0.02 m

Delivery line Length,L=0.03 m

r.p.m, N =3000

Q= ¼* 3.141 *$(0.02^2) * 0.03 * 3000/2$

=0.01 m^3/ min



Solar efficiency η graph

2.2 Experiment results:-

From graphs, we can see that the solar radiation fluctuates till 7 am to 5 pm but after that it maintains a steady value. This may be due to the cloudy forecast that we had on that day.

In respond to the radiation fluctuation, the flow rate also fluctuates till 5.00 pm, and after that it maintains a steady balance value
Practically there was no water pumping below 18 watt/sqm.So the critical radiation is 18 watt/s.

To evaluate my project ,I followed the above mentioned steps using the data obtained during our observation of the project at BARI.

All currency is mentioned in dollar for better understanding of the project viability. I preferred off grid technology as our system was not connected to any external grid.

2.3 Water Pumping:

My priority is to satisfy the irrigation need during the month of BORRO, as it is mostly grown in Bangladesh and needs to be planted during Nov-Dec.And there is scarcity of ground water during this time of the year.The pump parameters are calculated from the data.From chart we find that our pump delivers 22.04 $m^3$of water.

We require 11500 $\frac{m^3}{hectare}$ of water for BORO . So ,if we assume to run our pump 8 hours a day and for two and half months (75 days) then we need to pump 153.3 $m^3$of water daily.Our experiment pump drives only 0.01 $m^3$of water in 4 hours . So we can pump 0.02$m^3$of water in 8 hours ,which is sufficient for only 0.287 hectares of land .This data has been provided to the RETScreen and it thus gives us output as to how much daily and annual electricity will be needed for irrigating 0.287 hectares of land.The output provided is 50 W of electricity.

2.4 Energy model:

In this portion ,I highlighted on the load that our system has to provide.The only load is a 35 W centrifugal pump.Both loads for the proposed case(solar irrigation) and the Base case(diesel engine irrigation) are assumed to be same .

I used Tk 72 as the current diesel price in Bangladesh. The experiment set up has 50 watt si-monocrystalline solar panel with an efficiency of approx. 95.3% . battery is used as energy is stored and no inverter is used as we are using a DC pump. Pump replacement (500 Dollar) and contingencies of 10%. The contingency allowance should be included to account for unforeseen annual expenses and will depend on the level of accuracy of the operation and maintenance cost estimate section. It typically ranges from 10 to 20% of thes costs.We have taken 10%of contingency.The cost analysis is shown in figure.

Initial costs (credits)	Unit	Quantity	Unit cost	Amount	Relative costs
Feasibility study					
Feasibility study	cost	0	$ -	$ -	
Subtotal:				$ -	0.0%
Development					
Development	cost			$ -	
Subtotal:				$ -	0.0%
Engineering					
Engineering	cost	1	$ 65	$ 65	
Subtotal:				$ 65	3.0%
Power system					
Photovoltaic	kW	0.75	$ 900	$ 675	
Road construction	km	0		$ -	
Transmission line	km	0		$ -	
Substation	project	0		$ -	
Energy efficiency measures	project	0		$ -	
Boring	cost	1	$ 300	$ 300	
Support structure	cost	1	$ 375	$ 375	
Subtotal:				$ 1,350	62.9%
Balance of system & miscellaneous					
Spare parts	%	0.0%		$ -	
Transportation	project	1	$ 25	$ 25	
Training & commissioning	p-d	0		$ -	
Pump & motor	cost	1	$ 500	$ 500	
Contingencies	%	10.0%	$ 1,940	$ 194	
Interest during construction	12.00%	1 month(s)	$ 2,134	$ 11	
Subtotal:				$ 730	34.0%
Total initial costs				$ 2,145	100.0%

Annual costs (credits)	Unit	Quantity	Unit cost	Amount
O&M				
Parts & labour	project	0	$ -	$ -
User-defined	cost			$ -
Contingencies	%	0.0%	$ -	$ -
Subtotal:				$ -

Annual savings	Unit	Quantity	Unit cost	Amount
Fuel cost - base case				
Diesel (#2 oil)	L	314	$ 0.932	$ 292
Subtotal:				$ 292

Periodic costs (credits)	Unit	Year	Unit cost	Amount
Pump replacement	cost	10	$ 500	$ 500
pump overhauling	cost	0	$ -	$ -
End of project life	cost		$ -	$ -

Go to Emission Analysis sheet

2.5 Emission Analysis:-

As part of the RETScreenClean Energy Project Analysis Software, an Emission Analysis worksheet is provided to estimate the greenhouse gas emission reduction (mitigation) potential of the proposed project. It also provides GHG global warming potential factors. The Base case electricity system and Base case system GHG summary sections provide a description of the emission profile of the baseline system. The Proposed case system GHG summary section provides a description of the emission profile of the proposed project. The GHG emission reduction summary section provides a summary of the estimated GHG emission reduction based on the data entered by the user in the preceding sections. Results are calculated as equivalent tones of CO2 avoided per annum.

The emission reduction of our project is shown in figure

○ Method 1
◉ Method 2
○ Method 3

Global warming potential of GHG

25 tonnes CO2 = 1 tonne CH4	(IPCC 2007)
298 tonnes CO2 = 1 tonne N2O	(IPCC 2007)

Base case system GHG summary (Baseline)

Fuel type	Fuel mix %	CO2 emission factor kg/GJ	CH4 emission factor kg/GJ	N2O emission factor kg/GJ	Fuel consumption MWh	GHG emission factor tCO2/MWh	GHG emission tCO2
Diesel (#2 oil)	100.0%	73.3	0.0020	0.0020	3	0.266	0.8
Total	100.0%	73.3	0.0020	0.0020	3	0.266	0.8

Proposed case system GHG summary (Power project)

Fuel type	Fuel mix %	CO2 emission factor kg/GJ	CH4 emission factor kg/GJ	N2O emission factor kg/GJ	Fuel consumption MWh	GHG emission factor tCO2/MWh	GHG emission tCO2
Solar	100.0%	0.0	0.0000	0.0000	1	0.000	0.0
Total	100.0%	0.0	0.0000	0.0000	1	0.000	0.0

Table : 1.3 (Emission Analysis)

As we see, our project reduces carbon di oxide use by 0.8 ton. It also resembles this statistics as other parameter. Reducing carbon- di- oxide use by 0.8 tones resembles 344 liters of gasoline not being consumed.

GHG emission reduction summary							
	Base case GHG emission tCO2	Proposed case GHG emission tCO2			Gross annual GHG emission reduction tCO2	GHG credits transaction fee %	Net annual GHG emission reduction tCO2
Power project	0.8	0.0			0.8		0.8
Net annual GHG emission reduction	0.8	tCO2	is equivalent to	344	Litres of gasoline not consumed		

Table: 1.4 (GHG Emission Reduction summary)

2.6 Financial Analysis:

One of the primary benefits of using the RETScreen software is that it facilitates the project evaluation process for decision-makers. The Financial Analysis worksheet, with its financial parameters input items (e.g. discount rate, debt ratio, inflation rate , discount rate ,etc.), and its calculated financial viability output items (e.g. IRR, simple payback, NPV, etc.), allows the project decision-maker to consider various financial parameters with relative ease. Discount rate (10%) which is the rate used to discount future cash flows in order to obtain their present value. The rate generally viewed as being most appropriate is an organisation's weighted average cost of capital. An organisation's cost of capital is not simply the interest rate that it must pay for long-term debt. Rather, cost of capital is a broad concept involving a blending of the costs of all sources of investment funds, both debt and equity. The discount rate used to assess the financial viability of a given project is sometimes called the "hurdle rate," the "cut-off rate," or the "required rate of return."

In our project, we have taken the inflation rate as 7.5 (World Bank 2013), fuel escalation rate as 6.0%. We have also taken the project life to be 20 years.The total project being financed by the owner itself so no grant or subsidy is taken into account. The annual income which considered is only that of GHG reduction.

RETScreen Financial Analysis - Power project

Financial parameters		
General		
Fuel cost escalation rate	%	6.0%
Inflation rate	%	7.5%
Discount rate	%	10.0%
Project life	yr	20
Finance		
Incentives and grants	$	0
Debt ratio	%	0.0%
Income tax analysis	☐	

Table: 1.5 (Financial model)

Many of the summary items here are calculated and/or entered in the ***Cost Analysis worksheet and transferred to the Financial Analysis worksheet***. The remainder are calculated and/or entered in other parts of the ***Financial Analysis worksheet***.

The total initial costs represent the total incremental investment that must be made to bring the proposed case project on line, before it begins to generate savings and/or income. The total initial costs are the sum of the estimated feasibility study, development, engineering, power system.

The total annual costs are calculated by the model and represent the yearly costs incurred to operate, maintain and finance the project. It is the sum of the O&M, fuel cost for the proposed case system and debt payments

The periodic costs and periodic credits are entered by the user in the *Cost Analysis* worksheet and are transferred here. The model escalates the periodic costs and credits yearly according to the inflation rate starting from year 1 and throughout the project life.

Project costs and savings/income summary			
Initial costs			
Engineering	3.0%	$	65
Power system	62.9%	$	1,350
Balance of system & misc.	34.0%	$	730
Total initial costs	**100.0%**	**$**	**2,145**
Annual costs and debt payments			
O&M		$	0
Fuel cost - proposed case		$	0
Total annual costs		**$**	**0**
Periodic costs (credits)			
Pump replacement - 10 yrs		$	500
Annual savings and income			
Fuel cost - base case		$	292
Total annual savings and income		**$**	**292**

Table: 1.6 (Financial model)

The results from the financial viability portion provide the decision-maker with various financial indicators for the proposed case project.

The model calculates the pre-tax internal rate of return (IRR) on equity (%), which represents the true interest yield provided by the project equity over its life before income tax. If the internal rate of return is equal to or greater than the required rate of return of the organization, then the project will likely be considered financially acceptable (assuming equal risk). If it is less than the required rate of return, the project is typically rejected.

Financial viability		
Pre-tax IRR - equity	%	16.8%
Pre-tax IRR - assets	%	16.8%
After-tax IRR - equity	%	16.8%
After-tax IRR - assets	%	16.8%
Simple payback	yr	7.3
Equity payback	yr	6.0
Net Present Value (NPV)	$	1,198
Annual life cycle savings	$/yr	141
Benefit-Cost (B-C) ratio		1.56
GHG reduction cost	$/tCO2	(167)

Table: 1.7 (Financial viability)

Equity payback was referred to "Year-to-positive cash flow"The model calculates the simple payback (year), which represents the length of time that it takes for a proposed project to recoup its own initial cost, out of the income or savings it generates. The simple payback method is not a measure of how profitable one project is compared to another. Rather, it is a measure of time in the sense that it indicates how many years are required to recover the investment for one project compared to another

The model calculates the Net Present Value (NPV) of the project, which is the value of all future cash flows, discounted at the discount rate, in today's currency. The difference between the present values of these cash flows, called the NPV, determines whether or not the project is generally a financially acceptable investment. Positive NPV values are an indicator of a potentially feasible project

The model calculates the net Benefit-Cost (B-C) ratio, which is the ratio of the net benefits to costs of the project. Net benefits represent the present value of annual income and savings less annual costs, while the cost is defined as the project equity. Ratios greater than 1 are indicative of profitable projects.

The model calculates the GHG reduction cost. The GHG reduction cost is calculated by dividing the annual life cycle savings of the project by the net GHG reduction per year, averaged over the project life.

The total annual savings and income represents the annual savings and/or income realized due to the implementation of the proposed case system.

The model calculates the annual GHG reduction income, which represents the income generated by the sale or exchange of the GHG reduction. This value is calculated from the annual net GHG reduction and the GHG reduction credit rate. The yearly value of GHG reduction income is escalated at the GHG reduction credit escalation rate.

Annual income		
Electricity export income		
GHG reduction income		☐
Net GHG reduction	tCO2/yr	1
Net GHG reduction - 20 yrs	tCO2	17

The software also provides us with the yearly cash flow .Thus showing us the positive cash flow and the year it takes to attain that. For our project, the positive cash flow occurs at the 6th year and after 20 years of the project the project will generate about 6104 dollar.

Yearly cash flows			
Year	Pre-tax	After-tax	Cumulative
#	$	$	$
0	-2,145	-2,145	-2,145
1	310	310	-1,835
2	329	329	-1,506
3	348	348	-1,158
4	369	369	-789
5	391	391	-397
6	415	415	18
7	440	440	457
8	466	466	924
9	494	494	1,418
10	-507	-507	911
11	555	555	1,466
12	588	588	2,054
13	624	624	2,678
14	661	661	3,339
15	701	701	4,040
16	743	743	4,783
17	788	788	5,571
18	835	835	6,406
19	885	885	7,290
20	-1,186	-1,186	6,104

Table: 1.8 (Financial model)

The graph in Figure shows the cumulative cash flow over the project life.

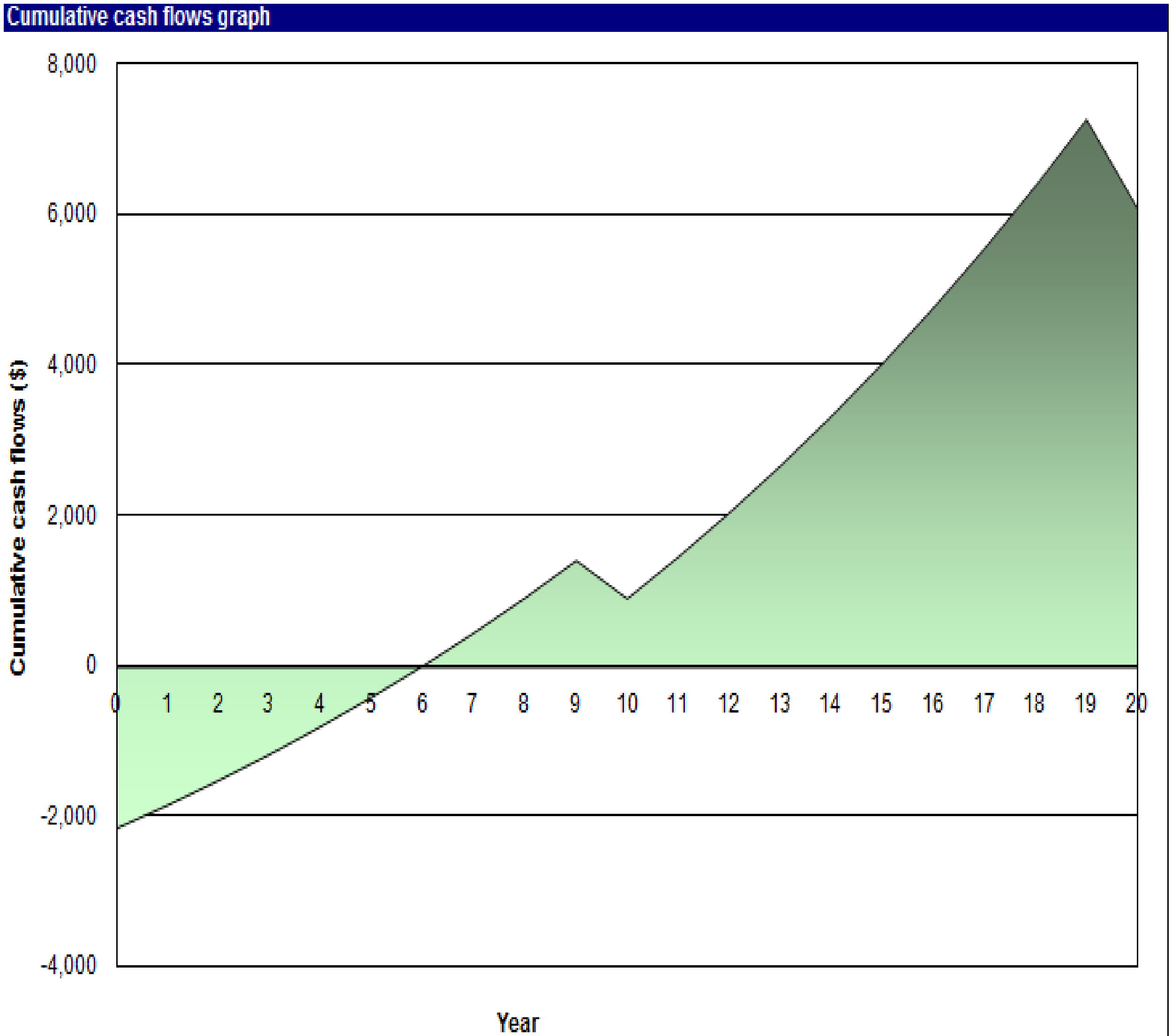


Figure: 1.4 (Cash Flow)

2.7 Sensitivity and Risk Analysis:

As part of the RETScreen Clean Energy Project Analysis Software, a Sensitivity and Risk Analysis worksheet is provided to help the user estimate the sensitivity of important financial indicators in relation to key technical and financial parameters. This standard sensitivity and risk analysis worksheet contains a settings section and two main sections: Sensitivity analysis and Risk analysis. Each section provides information on the relationship between the key parameters and the important financial indicators, showing the parameters which have the greatest impact on the financial indicators. The Sensitivity analysis section is intended for general use, while the Risk analysis section, which performs a Monte Carlo simulation, is intended for users with knowledge of statistics.

This section presents the results of the sensitivity analysis. Each table shows what happens to the selected financial indicator (e.g. After-tax IRR – equity) when two key parameters (e.g. Initial costs and O&M) are varied by the indicated percentages. Parameters are varied using the following fraction of the sensitivity range: -1, -1/2, 0, 1/2, 1. Original values (which appear in the *Financial Analysis* worksheet) are in bold in these sensitivity analysis results tables. Results which indicate an unviable project, as defined by the user.Threshold, will appear as orange cells in these sensitivity analysis results table.

RETScreen Sensitivity and Risk Analysis - Power project

Sensitivity analysis

Perform analysis on	Net Present Value (NPV)	
Sensitivity range	10%	
Threshold	1,198	$

Fuel cost - base case				Initial costs		$
		1,930	2,037	2,145	2,252	2,359
$		-10%	-5%	0%	5%	10%
263	-10%	1,007	899	792	685	578
278	-5%	1,209	1,102	995	888	780
292	0%	1,412	1,305	**1,198**	1,090	983
307	5%	1,615	1,508	1,400	1,293	1,186
322	10%	1,818	1,710	1,603	1,496	1,389

Fuel cost - proposed case				Initial costs		$
		1,930	2,037	2,145	2,252	2,359
$		-10%	-5%	0%	5%	10%
0	-10%	1,412	1,305	1,198	1,090	983
0	-5%	1,412	1,305	1,198	1,090	983
0	0%	1,412	1,305	**1,198**	1,090	983
0	5%	1,412	1,305	1,198	1,090	983
0	10%	1,412	1,305	1,198	1,090	983

Debt interest rate				Initial costs		$
		1,930	2,037	2,145	2,252	2,359
%		-10%	-5%	0%	5%	10%
0.00%	-10%	1,412	1,305	1,198	1,090	983
0.00%	-5%	1,412	1,305	1,198	1,090	983
0.00%	0%	1,412	1,305	**1,198**	1,090	983
0.00%	5%	1,412	1,305	1,198	1,090	983
0.00%	10%	1,412	1,305	1,198	1,090	983

Table: 1.9 (Sensitivity model)

The above chart shows the range of sensibility for which our NPV will still be feasible to accept this project.The orange color cells represent the viability range of the change of parameters.In the risk analysis section, the impact of each input parameter on a financial indicator is obtained by applying a standardized multiple linear regression on the financial indicator. This section allows the user to perform a risk analysis by specifying the uncertainty associated with a number of key input parameters and to evaluate the impact of this uncertainty on after-tax IRR - equity, after-tax IRR - assets, equity payback or Net Present Value (NPV).

The risk analysis is performed using a Monte Carlo simulation that includes 500 possible combinations of input variables resulting in 500 values of after-tax IRR - equity, after-tax IRR - assets, equity payback or Net Present Value (NPV). The risk analysis allows the user to assess if the variability of the financial indicator is acceptable, or not, by looking at the distribution of the possible outcomes. An unacceptable variability will be an indication of a need to put more effort into reducing the uncertainty associated with the input parameters that were identified as having the greatest impact on the financial indicator.

☑ Risk analysis

Perform analysis on: Net Present Value (NPV)

Parameter	Unit	Value	Range (+/-)	Minimum	Maximum
Initial costs	$	2,145	10%	1,930	2,359
Fuel cost - base case	$	292	10%	263	322
Debt term	yr	0	0%	0	0

Table: 1.10 (Risk model)

Median	$	1,192
Level of risk	%	10.0%
Minimum within level of confidence	$	963
Maximum within level of confidence	$	1,437

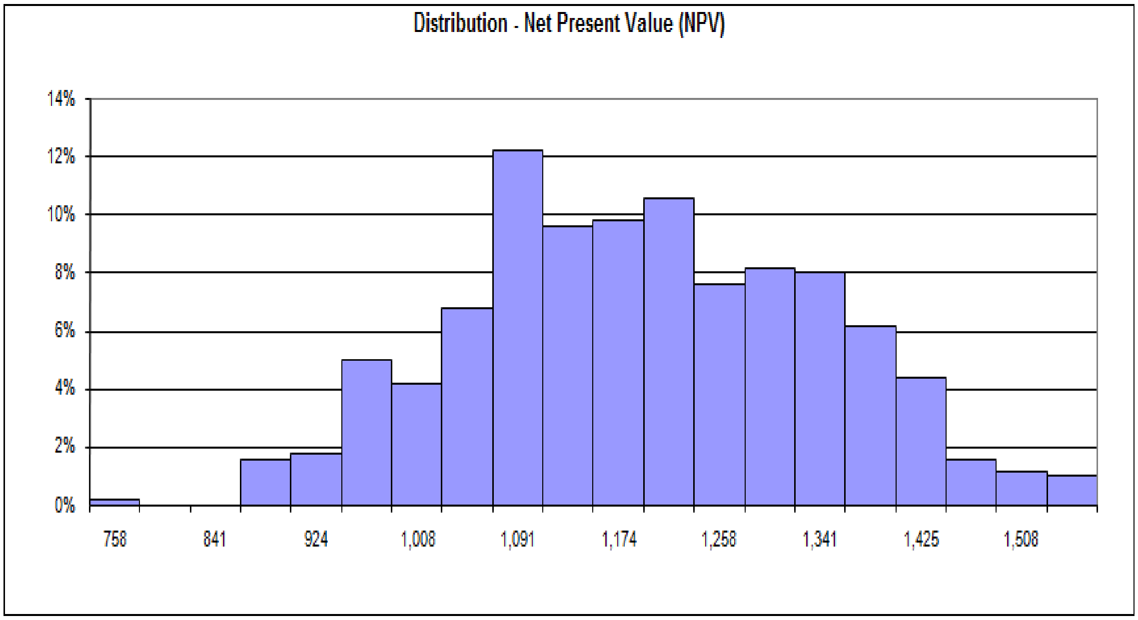


Table : 1.11 (Monte Carlo distribution)

The above chart represents the range of values of NPV (1437-963) dollar, for which our project has the viability.

2.8 How can we irrigate 10 bighas land

To Irrigate 10 bighas land with solar we have to need 1KW solar panel,High capacity inverter, high power battery,15 hp AC motor pump.We have to need AC system totally. Solar gives us DC output ,to AC we need inverter. We know 35W motor pump gives us 0.01m^3/m water so 15hp pump gives us 3.53m^3/m. Inverter gives us 11KW power. With pump flow rate we can irrigate 10 bighas of land easily in full sunny day.

CHAPTER 3

VIABILITY OF THE PROJECT AND CONCLUSION

3.1 Viability of the project:-

Positive NPV values are an indicator of a potentially feasible project our NPV value is (1437-963)dollar which represent the viability of the project.The graph of the cumulative cash flow over the project life also represent the financial viability of the project. Our experiment also reduce the emission of GHG effect.

3.2 Conclusion:

From our analysis it has been identified that solar irrigation system is feasible for small pumps for surface water irrigation .Well, no conclusion can be drawn if this solar system idea is also feasible for larger capacity of pump or submersible pump. It is also seen that after 6 years the project seems to become a way of income to the poor as it generates cash flows. The project would have been more profitable and feasible if the same system integral with a battery could be used to generate electricity during rainy season, as there is plenty of natural water for irrigation.