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A SOLAR POWERED DESALINATION SYSTEM FOR REMOTE REGION IN BANGLADESH

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Abstract- *Energy is the major criteria for the development and economic growth of a country. Bangladesh is one of the developing countries in Asia. About 32% of total population did not access electricity in Bangladesh and most of those people are rural peoples. Sweet water and electricity crisis is the major crisis of those rural or remote areas. About 97% water of the world is saline water, while the remaining 3% is sweet water. To upgrade a nation it is important to develop the remote regions with fresh water and electricity supply. Renewable source is the best way for alternative power generation and fresh water production. In this a small desalination system has been proposed with reverse osmosis process (RO) using renewable source (solar) for remote area in Bangladesh. For implementing the proposed system Sandwip Island has been chosen which is one the isolated and remote islands in Bangladesh.*

Keywords: *Green System; PV; Brackish water; RO; Desalination;*

1. INTRODUCTION

Water and Electricity are the two basic needs of a society. To develop a sustainable society firstly ensure their water and electricity demand. Bangladesh also trying to fulfill their fresh water and electricity demand. About 68% of total populations access electricity in Bangladesh [1]. Total generation is 9460MW. After 13 year our demand will be 30000MW [2]. The major power generation sources is natural gas and other are oil, coal, hydro, etc. which is conventional sources but those sources will be finished about 7-10 years. It's our duty to create different scope for solving upcoming power crisis. Most of those peoples are urban peoples. About 72% of total populations stay in rural and remote areas [3]. So, they can't use those types of modern facilities. For sustainable Bangladesh, simultaneously needed to upgrade their urban and remote communities and fulfill basic demand like electricity and fresh water.

The coastal regions in Bangladesh have been experiencing acute shortage of fresh drinking water and the salinity level of surface and underground water is high which reached in brackish water level. About 62% of coastal water is high saline (brackish, arsenic, etc) [4].

To fulfill electricity and fresh water demand in the coastal region, renewable energy is the best option and solar PV system is the economical for standalone or small scale power generation. Solar radiation in Bangladesh is about 4.63kWh/m2/day and sunshine is about 7-8 hour/day. There are various methods in water desalination system like RO, EDR, MSF, and VC. Reverse Osmosis desalination system is the cost economical system for underground water or brackish water purification system [5].

In this proposed system, to develop a specific system for solving water and electricity crisis in remote or coastal region. According to environmental, geographical situation and economical reason renewable solar PV system is the best alternative for brackish water reverse osmosis (BWRO) desalination [6]. To design, feasibility study and analysis, Sandwip is one of possible the best locations for the system

2. PROPOSED GREEN SYSTEM

2.1. Proposed Desalination System

The Reverse osmosis system is the most economical desalination system to produce sweet water from underground and sea water [7].

TABLE 1: SYSTEM COMPONENT SPECIICATION

Components	Capacity	Unit
1. Solar PV	400	W
2. Battery	2	kW
3. Charge Controller	24, 20	V, A
4. Brackish water Tube Well (Height)	20	m
5. HP Pump (DC)	24, 130	V,W
6. RO Machine	20	l/hr
7. Storage Tank	200	Liter

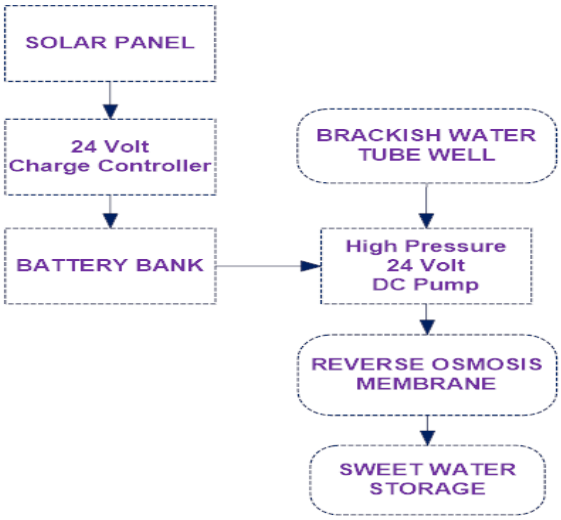

Fig. 1 Proposed Desalination System

The proposed system is design for coastal areas for fulfill their fresh water demand which is consists of renewable source (solar), brackish water tube well, storage tank, high pressure DC pump, reverse osmosis (RO) membrane, charge Controller, and battery and which is represented in fig. 1 and table 1 and elaborately discussion will be simulation and optimization section. The lifetime of the proposed system is 25 years.

2.2. Site Selection

Sandwip is 2nd big island in Bangladesh, which is totally isolated from the main stream. [8]. It is situated between 22.28' 04" north latitudes and 91.27' 22" east longitudes and the coastal area of Bangladesh [9]. Fig. 3 shows geographical location in Sandwip.

Fig. 2 Geographical Location in Sandwip

This island community peoples didn't access electricity, fresh water and modern facilities.

2.3. Proposed Demand Profile

Initially, the proposed system designed for 10 families. Every family has 5 members. So, the system mainly designed for 50 persons. According to world health organization (WHO), a person required 2litre/day water [10]. So, our demand will be 100litre/day. We want to establish a system which will produce 20L//hr. The operating time of the system is 5hr/day and daily power demand is 650W/day.

3. SIMULATION & OPTIMIZATION

Design, optimization and analysis, we have chosen homer software for solar system and IMS Design software used for RO system design [11-12].

3.1. Reverse Osmosis System Design

High pressure process driven process called reverse osmosis process. It is the most economical process for desalination because it recovers 20-70% salt water [13].The proposed brackish water total dissolved solid (TDS) is 4000mg/l. The input parameter of RO system presents in table 2. The proposed system will recover 60% of water. According to WHO the drinking water TDS limit upto 500mg/l and bangladesh Govt. TDS limit upto 1000mg/l.

TABLE 2: RO SYSTEM INPUT SPECIFICATION

Feed Water	33L/hr
TDS	4000mg/l
Temperature	25°C
Recovery	60%
Feed Pressure	122psi

3.2. Solar System Design

Solar photovoltaic system is the most economical and renewable power generation system for remote or isolated region. Photovoltaic cell converts sunlight into electricity as a DC power and store it by the battery. Then use it for DC load or DC pump. The average solar radiation in Bangladesh is about 4.63kWh/m^2/day and the lighting hour is about 7 hour [14]. Fig. 3 shows the solar system model.

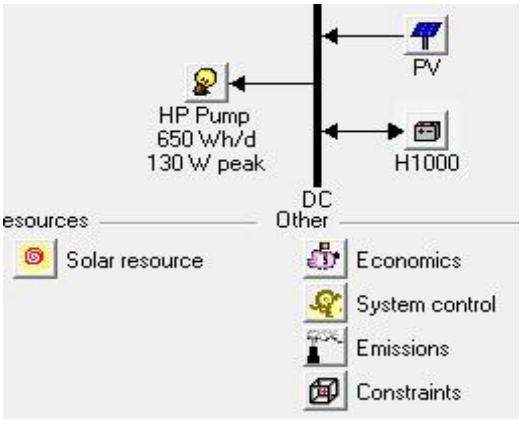

Fig. 3 Solar PV System Model

TABLE 3: PV CELL SPECIFICATION

Solar cell (Polycrystalline)	200W
Lifetime	25 yr
De-rating factor	80%
Slope	23.000 deg
Azimuth	0.000 deg
Ground reflectance	20.0%

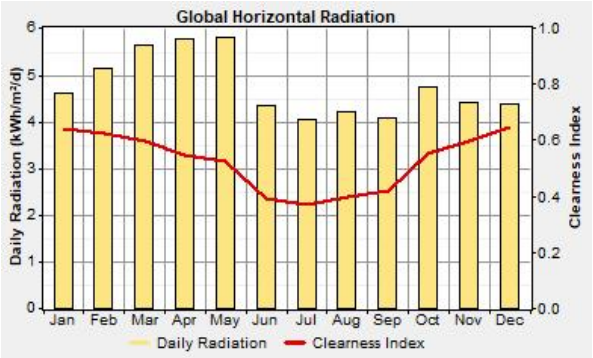

Fig. 4 Solar GHI Resource

The average solar radiation in Sandwip is about 4.76kWh/m^2/day and average clearness index is 0.512 [8]. It showed in Fig. 4 and solar cell specification presented in table 4.

4. RESULTS

4.1. RO System Output

The main target of the proposed system is to produce 20L/hr fresh water and 100L/day. After simulate and optimize all the parameter, the product TDS is 331.20mg/l which follows WHO requirement and the required pump of the system is 130w which shows in figure 5 and table 4

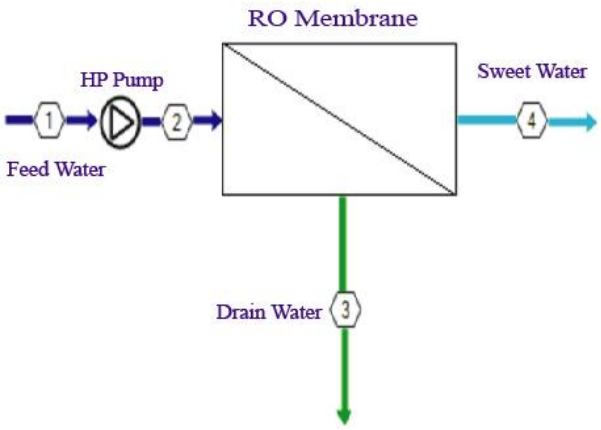

Fig. 5 RO Process Flow Diagram

TABLE 4: RO SYSTEM OUTPUT RESULT

Raw Feed	33L/hr
Product	20L/hr
Concentrate	13.27L/hr
Raw Feed TDS	4000.02mg/l
Product TDS	331.20mg/l
Concentrate TDS	10935.80mg/l
Main Pump (DC)	.013kW
Pump Consumption	6.5KW/m^3

4.2. Solar System Output

The required HP pump size is 130w and the operating time is 5 hour/day. Analysis all the parameter the rated capacity of the solar cell is 200w.

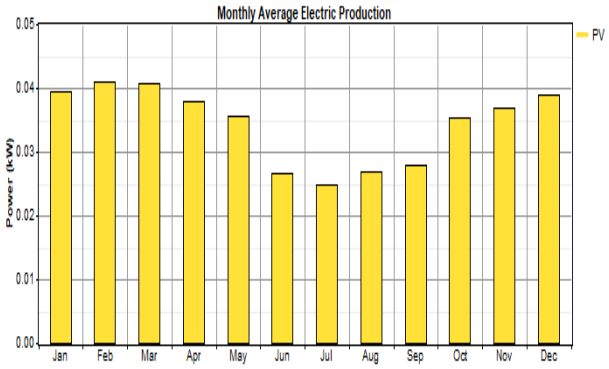

Fig. 6 PV Cell Output

TABLE 5: SOLAR POWER OUTPUT

Items	Value	Units
Rated capacity	0.200	kW
Mean output	0.03	kW
Mean output	0.824	kWh/d
Capacity factor	17.2	%
Total production	301	kWh/yr
Power Consumption	237	kWh/yr
Excess Electricity	53	kWh/yr
Hours of operation	4372	hrs/yr
Levelized cost	0.0293	$/kWh

The mean production of the system in a day is 824W/day which is represented in fig. 6 & table 5. Our target demand is 650W/day.

4.3. Economical Analysis

Initially, the installation, component and transportation cost of the system is very high about $670 and replacement cost of the system is about $977. Every 5-7 years battery will need to replace and 2-3 years RO Membrane will need to replace. Total cost of the system is $2832 which shown in Table 6 – 7 & figure 7. The maintenance cost of the system is $6.36/yr.

TABLE 6: TOTAL COST OF THE SYSTEM

Components	Initial Capital	Replacement	Operation & Maintenance
PV	$140	$37	$26
Battery	$130	$140	$38
Charge Controller	$30	$00	$00
HP Pump	$100	$00	$00
RO Membrane	$250	$800	$95
Storage Tank	$20	$00	$00
Total	$670	$977	$159

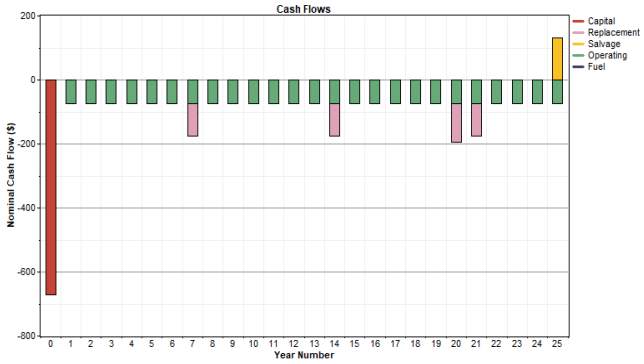

Fig. 7 Total Cost of the system

TABLE 7: OVERALL SUMMARY

Total Net Presents Cost	$2832
Total Levelized of Energy	$0.115
Total Levelized Cost Fresh Water	$2.90/m^3
Total Operating Cost	$6.36/yr

5. CONCLUSION

In this research work, we determined the cost effective desalination water purification system using solar power which is most effective for coastal region or remote region. In carry out all of the analysis, the desalination cost of per liter of water is $0.0029 which is effective than existing mineral water system in Bangladesh and the cost of energy of the system is $0.115 which is better than conventional quick rental power plant in bangladesh. This system is specially design for remote region but it helps to fulfill fresh water and electricity demand in all areas in Bangladesh.

6. ACKOWLEDGEMENT

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8. NOMENCLATURE

Symbol	Meaning	Unit
PV	Photovoltaic Cell	DC Power
RO	Reverse Osmosis	Unit less
HP	High Pressure	Psi
WHO	World Health Organization	
BWRO	Brackish water Reverse Osmosis	