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An Economic and sustainable planning of Bhasan Char as an Exclusive tourism spot with off-grid SMART Green Energy System

Taskina Nasrin, Md. Mohiuddin Uzzal

***Abstract*— Bhasan char is a coastal island at Hatiya Upzilla of Noakhali District. It is a single char which has been uncovered from the Bay of Bengal a few years back. An emergency humanitarian project implemented by the Bangladesh government at this coastal island "Bhasan Char", from September 2017, to temporarily rehabilitate a portion of incoming Rohingya refugees before they can repatriate to their homeland, Myanmar. Under this project, Government of Bangladesh (GoB) carried out land development, construction of embankment as well as other infrastructures. Upon repatriation of Rohingya's to Myanmar, we can use the developed land & surroundings as exclusive tourist zone. This paper is an outline to establish Bhasan Char as an exclusive tourist spot and a feasibility analysis of an off-grid hybrid energy generation system for this proposed tourism spot. Here, we had conducted a hypothetical zonal design, energy estimation, off-grid energy distribution, energy generation and a sustainable tariff plan for this exclusive zone in modular basis.**

Keywords*— Renewable energy, Tourism industry, Demand Side Management, Sustainable Tariff Plan, SMART Grid, Rohingya Refugees, Bhasan Char.

I. INTRODUCTION

Over the past six decades, Tourism has accomplished continuous growth and diversification for becoming one of the largest and fastest growing economic sectors in the world [1]. For many developing countries, Tourism has become one of the major earning source of foreign currency. Bangladesh is blessed with natural beauty, ranging from mountains to rivers to beaches to bio-diversity. Also it is rich in natural, cultural & religious heritage and its tradition of friendly and generous reception and entertainment of guests, visitors, or strangers is a potential additional attraction for tourists and travelers [1].

Approximately six-lakh (6 hundred thousand) tourists came Bangladesh to visit and enjoy its beauty in 2012 [2]. As the day passes, the development of the tourism industry increases significantly. According to World Travel & Tourism Council, the direct contribution of Travel & Tourism to GDP in 2017 was BDT427.5bn (2.2% of GDP) [3]. This was forecasted to rise by 6.1% to BDT 453.5bn in 2018. The direct contribution of Travel & Tourism to GDP is expected to grow by 6.2% to BDT 824.0bn (2.1% of GDP) by 2028 [3] as shown in Fig. 1 and Fig. 2. The economic activity generated by industries such as hotels, travel agents, airlines and other passenger transportation are the main contributor in this calculation.

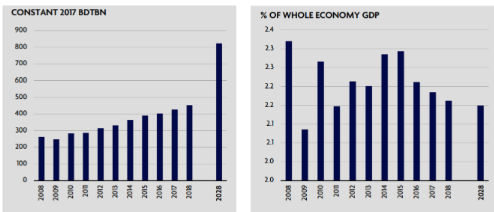

Fig.1: Bangladesh Direct Contribution of Travel & Tourism to GDP [3].

BANGLADESH	2017 USDmn[1]	2017 % of total	2018 Growth[2]	USDmn[1]	2028 % of total	Growth[3]
Direct contribution to GDP	5,310.4	2.2	6.1	10,235.7	2.1	6.2
Total contribution to GDP	10,567.4	4.3	6.4	21,777.6	4.6	6.8
Direct contribution to employment[4]	1,178	1.8	3.0	1,648	2.1	3.1
Total contribution to employment[4]	2,432	3.8	2.5	3,244	4.2	2.7
Visitor exports	228.5	0.6	6.3	444.9	0.7	6.2
Domestic spending	8,479.2	3.5	6.3	16,297.4	3.4	6.1
Leisure spending	7,414.8	1.9	6.4	14,428.0	1.8	6.2
Business spending	1,293.0	0.3	6.1	2,314.3	0.3	5.4
Capital investment	1,031.0	1.4	8.0	2,009.7	1.5	6.1

Fig. 2: Estimates and Forecasts [3].

Taskina Nasrin
Graduate Student; Dept. of EEE
American International University Bangladesh
Dhaka, Bangladesh
taskinanasrin@gmail.com

Md. Mohiuddin Uzzal
Professor; Dept. of EEE
American International University Bangladesh
Dhaka, Bangladesh
Email:drmohiuddin@aiub.edu

Bhasan char is a coastal island at Hatiya Upzilla of Noakhali District. It is a single char which has been uncovered from the Bay of Bengal a few years back. A humanitarian project has been implemented by the government of Bangladesh at this coastal island "Bhasan Char", from September 2017, to temporarily rehabilitate a portion of incoming Rohingya refugees before they can repatriate to their homeland, Myanmar [4]. Under this project, GoB carries out land development, construction of embankment as well as other infrastructures in the 30 acres of land among the 10000 acres [4]. The civil structures include building of houses, mosques, roads, water supply and sewage infrastructures, perimeter fencing, warehouses, fuel tanks, helipads, boat landing site, mobile phone towers and a radar station in Bhasan Char. Under the plan a power substation, solar panels and backup generators etc. will also be installed [4].

Upon repatriation of Rohingya's to Myanmar, we can reuse this land by making it residential area, or an exclusive tourist zone. This paper is an extension to the proposal to establish "Bhasan Char" as an exclusive tourism spot by adding some more artificially equipped and highly modern infrastructure for high-end tourism [5]. Here, we performed cost-energy analysis and tariff planning for sustainable operation of the proposed off grid hybrid energy system for Bhasan Char.

This paper is organized as follows: Section II outlines our Research Methodology and Section III details out the plan to establish Bhasan Char as a successful tourism spot. Section IV describes energy estimation for this exclusive zone narrating the feasibility of renewable sources, energy assessment and technical details of proposed system. The cost analysis and tariff planning are discussed in Section V. In Section VI, we proposed demand side management for the economic operation of the micro-grid. Section VII concludes the paper with discussion on the end results.

II. RESEARCH METHODOLOGY

This research is carried out on the feasibility of establishing a tourism spot & an off-grid sustainable energy system in coastal island Bhasan Char of Bangladesh to meet the demand for establishing it as a tourist allure. In forming the basis of the research work, the primary work was data collection from different sources, and analysis for renewable energy based system design. Whereas Planning, literature review, content analysis of relevant policies, research reports, case studies, journal articles, issues from print/electronic media and internet was the secondary attention. In Fig.3 the research methodology of this paper is summarized.

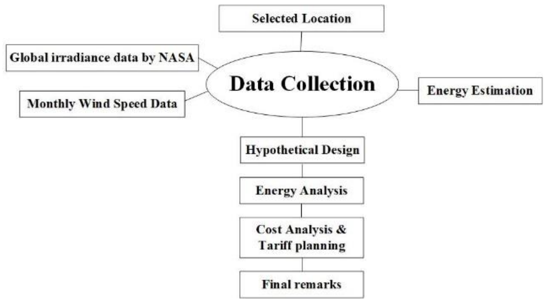

Fig. 3: Research Methodology.

III. BHASAN CHAR – A HYPOTHETICAL DESIGN

Tourism refers commercial operation of establishments with recreation facilities where people visit during holidays to renew energy and to refresh themselves from daily activities. Several types of tourism are there, which includes leisure tourism, cultural tourism, religious tourism, family tourism, sports tourism, educational tourism, business tourism etc. The tourism that we are proposing for Bhasan Char is coastal recreational tourism. This form of tourism is popular both in summer and winter season. For coastal tourism, a unique resource combination at the border of land & sea is required [6] i.e. Sun-water, beaches, outstanding scenic views, rich biological diversity (birds, whales, corals etc.), sea food & good transportation infrastructure etc. Based on these resources, various profitable services have been developed in many coastal destinations such as, well-maintained beach diving, boat-trips, bird watching tours, restaurants, food village, Cineplex, parks, or medical facilities. As, Bhasan char is located far south and starting point of Bay of Bengal that can be establish as a costal tourism spot by conducting proper modification, planning and implementation.

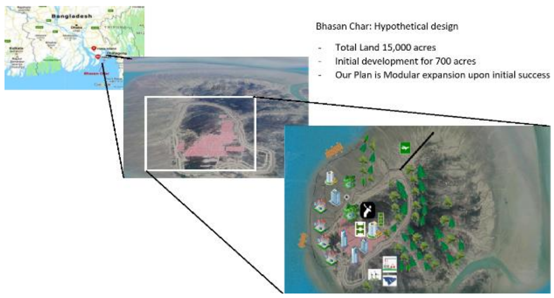

Fig. 4: Location of Bhasan Char and Its Land Development for Proposed Tourism.

As Bhasan Char is prone to tidal affect and the total size of the Char is around 15,000 acres during low tide whereas the size reduces to 10,000 acres during high tide. The total land development cost might not be economically feasible and for that reason we selected modular design of the tourism zone by starting with a land of around 700 acres in highland area of Bhasan Char [5].

As a densely populated country we don't have much tourism spots moreover highly equipped and managed spots. So, building a well-planned tourism spot, that will not only create recreational source and jobs but also will help grow the overall economy. Therefore, through proper design, expansion and development plan, we can make it a source of earning multi-million dollars in future. For any international standard tourism zone, we need exclusive and reliable facilities in addition to basic infrastructure and recreational amenities. Therefore, we have included exclusive recreational things like eco-park, costal sea beach, Hilsha fish, golf club, artificial park, hiking, wildlife creatures both in land and sea etc. in our hypothetical design.

Proposed area planning for Bhasan char is outlined below. Among total land area of 15000 acres, we have selected 3000 acres of land for developing the foundation & sectionalize it for different purposes. Our plan is to develop the whole region in modular basis. Upon success of initial plan, we will develop another 3000 acres in similar way.

The details plan of the 3000 acres' land area as below. We have reserved 1800 acres for hiking, beach area & forestation, 500 acres for energy park and remaining 700 acres are allocated for tourism related infrastructures like resorts, hotels, restaurants, theme park, Cineplex, cottage etc. The land division is summarized in Fig. 5.

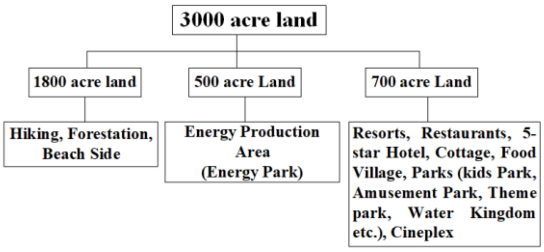

Fig. 5: Area Planning for Primary Module: Bhasan Char as Tourism Zone.

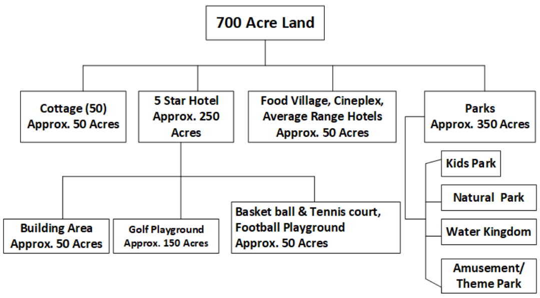

Fig. 6: Details Plan for Tourism Related Infrastructure.

Fig. 7: Hypothetical Design of the Tourism Spot [5].

We have selected 50 acres of land from 700 available in this module, for cottages. There we will have building area, private beachside zone for every single cottage & exclusive landscape; where tourists can enjoy the green scenic view by walking or roaming around the cottage. We are also planning a Five-star hotel with huge area (250 acres) which will be surrounded by some cottages, food villages, Cineplex, average range hotels and within the vast land of this five-star hotel, there will be golf playground, tennis and basketball court, football ground and hotel building etc. As this is a modular basis plan, upon demand we can expand this similar facility later. The number of bedrooms' ranges from 150 to 200 where rooms will be classified as high standard room, super deluxe room and standard room for single, double & family type rooms. There will be billiard board zone and pool board zone, table tennis zone etc. for indoor gaming.

We will also include some other facilities including kids zone, lake surface, medical center and masjid. As this will be built in a vast area, many types of vehicle services such as rickshaw ride, horse carriage etc. will be there to carry the tourists from one place to another and also for sight seen and roaming around this area. Hotel service includes shuttle services for the customers for board in & out. There will be some average range economic hotels like 3 star or 2-star hotels for average income people also and this will take 50 acres. There we will have around 150-200 bed capacity. For parks there will be 350 acres of land. Kids parks will specially be focusing on different themes such as kids gaming zone facility, roller coaster, cartoon network etc. Theme parks can have educational, regional, family-oriented themes including the flat rides like enterprise, tilt-a-whirl, graviton, chair-swing, swinging inverter ship, twister, top spin, roller coaster, Railways, water rides, dark rides, Ferris wheels, transport rides etc. Hypothetical area planning for “Bhasan Char” as a tourism spot is summarized in figure 6 and hypothetical design layout of the tourism spot is shown in figure 7 [5].

IV. Energy Estimation

This section briefly discusses about the feasible power sources predicted for this proposed power system, energy assessment and energy generation and distribution plan.

4.1 Feasible Power Sources-Solar and Wind

For sustainable social and economic development of a country, it must have adequate power generation capacity with effective fuel diversification. As part of Fuel Diversification Program Development, clean Renewable Energy is one of the important strategies adopted by GoB. Favorable Government policy aids Bangladesh to become the world's fastest growing country of Solar Home Systems (SHS) with a total installation of two million SHS that serves around 8.25 million people in the off-grid areas When we consider per unit generation costs, statistics shows that Installation cost of PV or wind energy system is comparable to conventional fossil fuel electricity [7].

Table 1: Monthly Solar Radiation(kWh/m2/day) and Wind Speed(m/s) data [7].

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Solar Radiation	4.42	4.98	5.44	5.51	5.11	4.16	4.04	4.18	4.02	4.28	4.25	4.28	4.55
Wind Speed	3	2.9	3.2	3.7	4.1	5.1	5.2	4.7	3.5	2.9	2.9	2.9	3.7

Attainment of United Nations Millennium Development Goals (UNMDG) and poverty alleviation of Bangladesh, largely depends upon improving access to energy. The government aims to improve energy intensity, primary energy consumption/GDP, by 20% in 2030 from that of 2013 level [7,8]. Our plan is to generate the required power from clean renewable sources because our proposed site for the exclusive tourist zone is surrounded by sea and we want to keep the pollution level minimum there - for the incoming tourists and as well as for residing humans, animals and other living beings. The wind and solar insolation data from NASA also shows that Bhasan Char is abundant with renewable sources of wind and solar. In Table 1 above, summarizes the monthly average wind speed and solar insolation data of Bhasan Char, where we have found an average monthly solar insolation of 4.55 kWh/m2/day and an average monthly wind speed is 3.7 m/s.

4.2 Energy Assessment

As part of our energy estimation, we conducted estimation by following a bottom-up approach. For energy estimation, we have considered the 700 acres that are demarcated for tourism related infrastructure such as 5-Star hotel, cottages, Cineplex, food village, Parks etc. that are mentioned in our hypothetical design. The other 1800 acres of land which we have proposed for hiking, beachside recreation and for forestation - don't need any energy requirement as this vast land will be reserved to be kept as natural as possible for outdoor activities. The details of the energy assessment are outlined below. Table 2, breakdowns the energy estimation for each of the cottages. Similarly, we did the bottom-up estimation for the only available 5-star hotel in the island and other available facilities too.

Table 2: Details Energy Estimation Breakdown for A Cottage.

Name	No. of Pieces	Hour	Watt /hour	Total Watt/day
Light general	2	8	60	960
Light Washroom	1	4	60	480
Light Kitchen	1	4	60	240
General Purpose Outlet	6	4	75	1800
Fan	2	8	150	2400
Fridge	1	24	200	4800
TV	1	8	100	800
Wi-Fi	1	24	20	480
IP Telephone	3	24	4	288
Geyser	2	3	4000	24000
Computer	1	8	400	3200
Electric Oven	1	1	3000	3000
Electric Burner	1	1	1000	1000
Electric Kitchen Appliances	1	1	100	100
Air Conditioner	1	8	1500	12000

Total				=55548 W =55.548K W

So, from the table 2, we found around 55KW energy needed for one cottage, then we consider the lighting facilities for outside, rooftop, veranda assuming for small, large & entertainment purpose lights 5KW, 1KW & 1KW there will be in total 30KW/day. Further, energy will be needed approximately 15KW/h so, 180KW/day power for those cottage area lighting like in grass, tree lighting, notice board, path direction cottage name, some sign etc. But here we assumed the time of consumption that can be different for other cottage so we used the utilization factor for making it more practical [9-11].

The power consumption of a load in normal operating conditions is sometimes less than that indicated as its nominal power rating, a fairly common occurrence that justifies the application of utilization factor in the estimation of realistic values [12].
Utilization Factor =The time that equipment is in use / The total time that it could be in use.

So, total approx. power needed for 15 cottages, (55*15KW+180KW+30KW) * .75=776.25KW

After conducting review of energy required for a similar 5-star facility, we estimated that we will require approximately 1.5 MW/day, [9-11] and for golf play-ground, tennis court, basket-ball and football court etc. will require another 1 MW/day for surrounding lighting and other daily necessities [10]. Therefore, we will require 2.5MW/day for the 5 Star hotel, which just matches with similar research paper as in [9-11]. This is a huge area of land where we should consider the interconnecting road lighting and lighting facility in between the free spaces of infrastructures, thus, we are allocating around 1 MW of energy for this lighting purpose. We have also allocated 0.5 MW for the Cineplex, average range hotels, food village, water kingdom etc. Considering an energy requirement of 2 MW for the associated parks, our total energy requirements for the primary module stands to 7 MW/ day as summarized in Fig. 8.

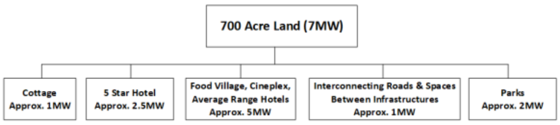

Fig. 8: Power Requirements.

4.3 Energy Distribution & Generation Plan

In the above section we have already estimated the required energy demand for this exclusive tourist zone, which is 7 MW/day or 7000 KWh/day. We are planning to generate it from clean renewable energy such as, solar & wind energy. Around 50% of the required energy will be generated from the Solar and the remaining 50% will be generated from wind. In our feasibility study [5], we have concluded that this island is more feasible for renewable energy generation with abundant supply of solar and wind. As we are considering having uninterrupted supply, we have plan to have backup facility. Therefore, this will be a highly equipped facility with uninterrupted supply of power 24/7 through backup energy sources such as Battery storage and Diesel Generator.

From our estimate of 7MW total demand, using utilization factor & considering the demand side management for a sustainable & economically viable operation we have decided to generate 5.5 MW capacity Power plant. Where decided to generate 2.75MW from Solar and rest 2.75 MW from wind. However, solar generated energy is of DC type whereas wind generation is of AC type. Therefore, we designed 2.75 MW converter system for the wind energy system to get DC from the both generation system. After that we can connect it directly on the DC load or connect on the ac load passing through an inverter [13-15].

For uninterrupted supply and to have proper backup we have decided to implement a system for 3 days' support from the battery storage with 2.7 Mega amp hour battery bank system. It is the most expensive component of the total energy management for this exclusive zone [15]. We can have this estimated backup from 6740 pieces of 12V 400 amp-hour battery. A charge controller is used to prevent overcharging and to protect against over-voltage. This charge controller also helps us to extend battery performance or lifespan. We also kept a 2.5MW diesel generator backup considering the worst case scenario such as weeklong disrupted weather in the island. Initially this diesel generator will not be connected with the system but when needed can be switched on as backup energy source. The whole energy generation plan as well as distribution and backup generation plan is summarized in the table 3 and in figure 9.

Table 3: Sizing of Power Plant

Serial	Requirements	Amount
1	Load demands	7000KW
2	Utilization factor	.75
3	Installed Capacity	5500KW
4	Solar	2500KW
5	Wind turbine	2500KW
6	Inverter	5500KW
7	Converter	2500kW
8	Battery storage	12V 400 amp hour

		(2250 pieces Battery)
9	Charge controller	5500KW
10	Diesel Generator	2500KW

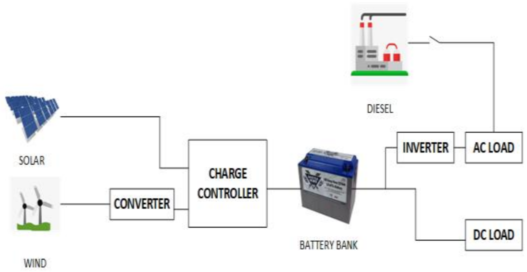

Fig. 9: Proposed System Configuration.

V. Energy Management Strategy:

A power management strategy is developed to improve reliability and power quality of the system. So, for this research first priority is given to wind energy since it can generate power both in day and night. However, solar PV is also considered to keep in operation depending on load demand. Initially diesel engine will not operate until their will any power shortage from solar PV or wind energy. As soon as the total generated power reaches their demand through the Solar & PV system the supervision system turns off the diesel engine [16]. The algorithm of supervision for power management can be expressed with the flow chart shown in Fig. 10:

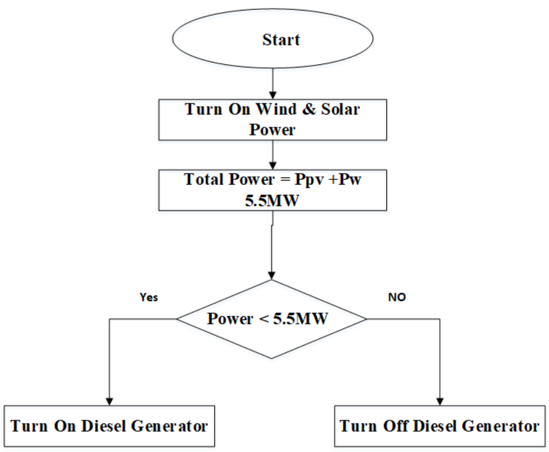

Fig. 10: Power Management Strategy.

VI. Cost Analysis & Tariff Planning

6.1 Cost Analysis:

For this proposed green energy system, cost analysis and tariff planning estimation were done using bottom-up concept as shown in Figure 11. The details of the calculation for capital expenditure is shown in Table 4 and the operation and maintenance schedule is shown in Table 5 and breakdown of all expenses in 20-year life-span is shown in Table 6.

The depreciation method that we followed for this project is Straight Line depreciation. The detailed planning of the proposed depreciation is shown in Table 7. We assumed a discount rate of 10 percent for Net Present Value (NPV) calculation. The NPV of the project is shown in Table 8. the 20 year cost annual wages etc. for finding the total investment for 20 years' lifespan given in the table 4,5 and 6. Finally with the help of some research paper we also estimate a tariff plan for this proposal and proved this project's viability.

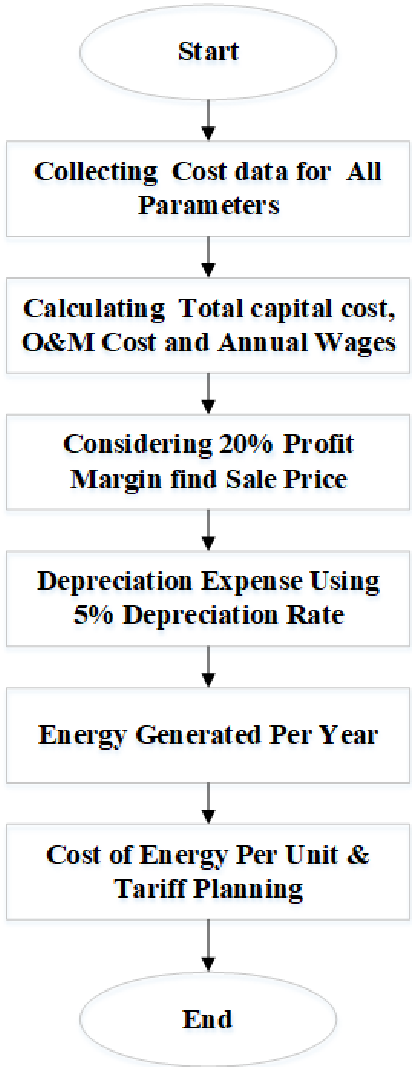

Fig. 11: Cost Flow Analysis.

Table 4: Total Capital Cost calculation for Parameters

Parameters	Unit	Value (TK)	Needed Amount	Capital cost (Tk. Million)	Lifespan (years)
Solar	KWH/BDT	100000	2750	275	20
Inverter	KWH/BDT	25000	5500	137.5	5
Wind Turbine	KW/BDT	109,200	2750	300.3	10
Converter	KWH/BDT	12000	2750	33	5
Battery	400Ampere hour	50000	6740	337	5
Charge controller	KWH/BDT	15000	5500	82.5	5
Diesel Generator	KW/BDT	6500	2750	16.25	15
Total				1181.55	

Table 5: Total Operational and Maintenance Cost calculation for all Parameters Per Year

Parameters	Unit	Value (TK)	Amount Needed	O & M cost(Million)
Solar	KW/BDT	1000	2750	2.75
Inverter	KW/BDT	500	5500	2.75
Wind Turbine	MW/BDT	1638	2750	4.5045
Converter	KW/BDT	500	2750	1.375
Battery	Piece/BDT	1000	6740	6.74
Charge controller	KW/BDT	1000	5500	5.5
Diesel Generator	KW/BDT	1000	2500	2.5
Total				26.1195

Table 6: Detail Cost Calculation for 20 years (Tk. In Million)

Year	Solar	Wind	Inverter	Converter	Battery	Charge controller	Diesel	O & M Cost	Annual Wages	Total	Total capital cost
1	275	300.3	137.5	33	337	82.5	16.25	26.1195	1	1208.6695	1181.55
2	0	0	0	0	0	0	0	26.1195	1	26.1195	0
3	0	0	0	0	0	0	0	26.1195	1	26.1195	0
4	0	0	0	0	0	0	0	26.1195	1	26.1195	0
5	0	0	0	0	0	0	0	26.1195	1	26.1195	0
6	0	0	137.5	33	337	82.5	0	26.1195	1	617.1195	590.0
7	0	0	0	0	0	0	0	26.1195	1	26.1195	0
8	0	0	0	0	0	0	0	26.1195	1	26.1195	0
9	0	0	0	0	0	0	0	26.1195	1	26.1195	0
10	0	0	0	0	0	0	0	26.1195	1	26.1195	
11	0	300.3	137.5	33	337	82.5	0	26.1195	1	917.4195	890.30
12	0	0	0	0	0	0	0	26.1195	1	26.1195	0
13	0	0	0	0	0	0	0	26.1195	1	26.11	0

										95	
14	0	0	0	0	0	0	0	26.1195	1	26.1195	0
15	0	0	0	0	0	0	0	26.1195	1	26.1195	0
16	0	0	137.5	33	337	82.5	16.25	26.1195	1	633.3695	606.25
17	0	0	0	0	0	0	0	26.1195	1	26.1195	0
18	0	0	0	0	0	0	0	26.1195	1	26.1195	0
19	0	0	0	0	0	0	0	26.1195	1	26.1195	0
20	0	0	0	0	0	0	0	26.1195	1	26.1195	0
Total cost										3810.49	3268.1

Table 7: Depreciation Cost Calculation for 20 years (Tk. In Million)

Year	Capital cost	Useful Life(Years)	Depreciation Expense(Cost/Year)	Accumulated Depreciation
				0
1	3268.1	20	163.405	163.405
2	3268.1	20	163.405	326.81
3	3268.1	20	163.405	490.215
4	3268.1	20	163.405	653.62
5	3268.1	20	163.405	817.025
6	3268.1	20	163.405	980.43
7	3268.1	20	163.405	1143.835
8	3268.1	20	163.405	1307.24
9	3268.1	20	163.405	1470.645
10	3268.1	20	163.405	1634.05
11	3268.1	20	163.405	1797.455
12	3268.1	20	163.405	1960.86
13	3268.1	20	163.405	2124.265
14	3268.1	20	163.405	2287.67
15	3268.1	20	163.405	2451.07
16	3268.1	20	163.405	2614.48
17	3268.1	20	163.405	2777.885
18	3268.1	20	163.405	2941.29
19	3268.1	20	163.405	3104.695
20	3268.1	20	163.405	3268.1

Table 8: NPV of the Project: 20 years Life-Span (Tk. In Million)

Year	Cash Flow	Discount Rate	$(1+K)^2n$	PV
1	261.1728	10%	1.1	237.4298182
2	261.1728	10%	1.21	215.8452893

3	261.1728	10%	1.331	196.2229902
4	261.1728	10%	1.4641	178.3845366
5	261.1728	10%	1.61051	162.1677605
6	261.1728	10%	1.7721561	147.3757306
7	261.1728	10%	1.949	134.003489
8	261.1728	10%	2.144	121.8156716
9	261.1728	10%	2.358	110.7603053
10	261.1728	10%	2.594	100.6834233
11	261.1728	10%	2.8531	91.54000911
12	261.1728	10%	3.1384	83.21845526
13	261.1728	10%	3.452	75.65840093
14	261.1728	10%	3.797	68.78398736
15	261.1728	10%	4.1772	62.52341281
16	261.1728	10%	4.595	56.83847661
17	261.1728	10%	5.0544	51.67236467
18	261.1728	10%	5.5599	46.97437004
19	261.1728	10%	6.1159	42.70390294
20	261.1728	10%	6.7274	38.82224931
Total				2223.424644

NPV = (Initial Investment – Sum of the all Discounted Cash flow)
= (3810.49-2223.424644) Tk.
= 1587.065 Million Tk.
NPV is positive which indicates the project is economically viable.
Here,
For 20 years' total investment cost = 3810.49 Million Tk.
Annual Wages & taxes = 1 Million Tk.
Annual Operation & maintenance cost = 26.1195 Million Tk.

1-year Capital Cost = 3810.49 /20 = 190.5245 Million Tk.
Considering Capital Cost, O&M and Annual Wages for 1-year Total Cost will be = (190.5245 +26.1195 +1) taka = 217.644 Million Tk.
Considering 20% Profit Margin Earning should be = (217.644 *1.2) taka = 261.1728 Million Tk.
So, Earning/Sale Price from this project should be = 261.1728 Million Tk. /year.

After that for finding the Cost Generating per Unit at first we have to know the no of units will be generated per year from this power plant because,
Cost of Energy (CoE)/unit=Sale Price/Energy Generated per unit

Unit generated per Year from Solar & Wind:
For Solar,
No of Units = System Capacity *No of Sunlight Hours
= (3500KW * 6Hours)

= 21000units

So, no of Units/Year = (21000 * 365) units
= 7665000 units

For wind,
Considering 30% Efficiency Factor
No of Units per year = (3500KW * 8760Hours * .30)
= 9198000 units
Total Units = (7665000 units + 9198000 units)
= 16863000 units =16.863 Mega units.

CoE/Unit = (261.1728 /168.63) Million Tk./Mega. units
= 15.4879203 Tk.

Therefore, Average Cost of Energy per Unit is approximately 16 Tk.

6.2 Tariff Planning

We have assumed a Profit Margin of 20% on our capital investment as discussed in previous section and shown in Figure 11. Therefore, for sustainable operation of the proposed off-grid hybrid generation system an average cost of energy per unit of 16 Taka is sufficient. The CoE/unit of 16 Taka might seem to be a little bit high. However, considering the ecology, off-grid green energy and the high reliability of the system with a lucrative return of 20% on investment, it sounds justifiable. As a reference, we can mention that Purobi Green Energy Limited (PGEL) in Bangladesh has a tariff plan at Taka 32/kWh for an off-grid green energy in Sandheap [20].

In Our proposed tariff plan, we will set a diversification to promote economic growth. For residential small consumers, we will set a flat rate of Taka 15/ unit. For commercial users, we will set a flat rate of Taka 16/unit. As it is a coastal island, we discourage power extensive industrial growth and therefore, we propose a tariff plan of Taka 20/unit for industrial users. We wanted to accommodate the small residential and commercial enterprises in our tariff plan. As the Large or bulky users can generate their own required power more economically, we are encouraging them towards that end with higher tariff.

Our proposed Tariff plans is shown in table 9, where we estimated 3 types of energy consumer residential, commercial and industrial. Demand charge and service charge also included on the table. Service charge refers the monthly cost of providing an electric meter, reading and servicing the meter, producing bills, and maintaining customer records. Customers are also billed for their demand (kW) for electricity along with their kilowatt-hour (kWh) consumption. The demand charge is associated with the highest amount of electricity required at any one given time within a particular month. Energy Producers must have sufficient electricity and the proper equipment available (such as generating facilities, distribution lines, and transformers) to meet the customer's maximum demand or load requirement. The demand charge is designed to cover these costs [22].

Table 9: Proposed Tariff Planning

SL	Customer Category	Tariff Per Unit Rate	Demand Charge	Service Charge
1	Residential Customer			
	Flat Rate	15 Tk.	25 Tk.	20 Tk.
2	Commercial Customer			
	Flat Rate	16 Tk.	30 Tk.	40 Tk.
3	Industrial Customer			
	Flat Rate	20 Tk.	40 Tk.	65 Tk.

VII. Demand Side Management

Demand side management (DSM) focuses on utilizing power saving technologies, electricity tariffs, monetary incentives, and government policies to mitigate the peak load demand instead of enlarging the generation capacity or reinforcing the transmission and distribution network [23].In section III we had estimated required demand of 7 MW energy per day for this tourism spot. However, considering the utilization factor and potential DSM techniques, we decided to generate 5.5 MW energy per day. To mitigate system instabilities from increased the electricity demand, we propose demand side-management tools and techniques to change the shape of the load demand curve by- shifting the peak loads to off-peak time through integration of SMART grid techniques in electrical systems of Bhasan Char. This SMART grid integration will reduce the overall operational and maintenance cost of the network by on-line monitoring and control of parameters in the network.

Electricity demands of residential, commercial and industrial users can be shifted and altered between peak and off-peak times by means of six broad DSM techniques [23], which are - peak clipping, valley filling, load shifting, strategic conservation, strategic load growth, and flexible load shape, as illustrated in Fig.12. Load shifting takes advantage of time-independence of loads, and shifts loads from peak time to off-peak time. Load building optimizes the daily response in case of large demand introduction beyond the valley filling technique. Peak clipping and valley filling focus on reducing the difference between the peak and valley load levels to mitigate the burden of peak demand and increase the security of smart grid.

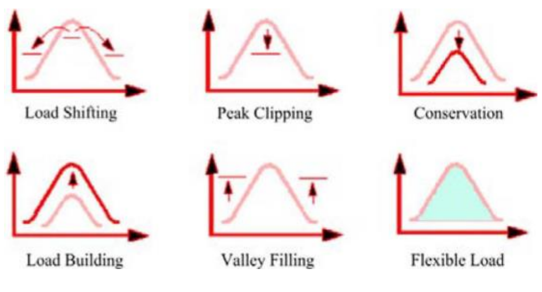

Fig. 12: Demand side management techniques [23].

Conservation techniques aims to achieve load shape optimization through application of demand reduction methods directly at customer premises through energy conversion and storage systems. In Flexible load shape management techniques, Smart grid management systems identify customers with flexible loads that are willing to be controlled during critical periods in exchange for various incentives [23]. We can choose any of the techniques mentioned above to manage demand side in Bhasan Char.

VIII. CONCLUSIONS

This research is a proposal to establish Bhasan Char as an exclusive tourism spot on modular based design as a pilot project. Upon repatriation of the Rohingya refuges to Myanmar in future – the infrastructures in Bhasan Char might be reused for profit generating economic activities. As part of the proposal, we have carried out a hypothetical design of an exclusive tourist zone in modular basis. We had also calculated the energy requirement for the exclusive zone. Our primary module is designed on 3000 acres of land and our estimated energy requirements are 7 MW/day generated through renewable sources i.e. wind and solar. However, including utilization factor, diversification and DSM method we concluded to generate 5.5 MW/day with equal generation from wind and solar. We also have provision for a diesel generation to backup emergency situations. We performed a cost analysis for economic and sustainable operation of the tourist with a reasonable profit margin of 20% per year. Total investment required for the zone is approximately Taka 382 crore (USD 4.53 crore), which is equivalent to Taka 158.7 crore if discounted over 20 years with a discount rate of 10 percent. Our proposed tariff plan supports a 20% profit margin from overall consumption with a strategic goal to promote economic growth by encouraging accommodation of residential and commercial users with lower tariff charge. We had proposed a flat rate tariff plan for residential, commercial and industrial customers at 15Tk./unit, 16Tk./unit, and 20Tk./unit respectively. To keep the investment to an optimal level with sound return, we also want to include demand side management techniques for this exclusive proposed tourist zone by accommodating maximum number of users through smart management of generation, distribution, tariff and load inclusion and load exclusion with proper incentive. Therefore, this can be considered as a complete plan to establish Bhasan Char as an exclusive tourist zone with an overall plan on modular based zone development, energy estimation, cost analysis, tariff plan for sustainable operation, sustainable strategy for economic growth and with a plan to incorporate Smart Grid Management for most optimal utilization of the zone.

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Taskina Nasrin, earned her Bachelor of Science in Electrical and Electronic Engineering from American International University Bangladesh (AIUB) in 2017. She received academic scholarship for her result in B.Sc. Program and also received prestigious 'Cum Laude' distinction for her excellent academic record in undergraduate program. Recently, she is continuing her M.Sc. thesis under the conversant supervision of Professor Dr. Mohammad, Mohiuddin Uzzal, AIUB and her research interest mainly focuses on renewable technology, power electronics, HVDC systems, Power Generation, Distribution & Transmission System, Smart Grid System etc.

Mohammad Mohiuddin Uzzal received B.Sc. degree in Electrical and Electronic Engineering from BUET, Dhaka, Bangladesh in 2002 and M.S.E. degree in Electrical Engineering from Arizona State University (ASU), USA in 2006. He worked as a research assistant while pursuing a Ph.D. degree in micro-electronics with a research focus in mixed signal CMOS circuits for Bio-sensing application at University of New Mexico, NM, USA. From 2004 to 2012, he was with American International University - Bangladesh as a Full-time Faculty in Electrical and Electronic Engineering Department. From May to Dec. 2014, he was with Intel Corporation, Santa Clara, CA and worked on next generation high speed (10-16Gbps) I/O design and simulation. His research interest includes analog/RF and mixed signal circuit design, low cost bio-sensors and Nano-electronics. He holds a professional MBA degree from Institute of Business Administration, University of Dhaka, in 2008.