An Applicable Implementation Policy for "Consumer is Producer" Model

Alimul Haque Khan, Md.Maidul Islam, Ashraful Haider Chowdhury, Md.Saifur Rahman

Abstract— The power market of Bangladesh as well as many other countries is still locked for the common people. Selling energy to the grid is yet not so easy for them. It needs a lot of investment to enter into the power market. As a result, few of the population have the scope to sell the generated energy. The model "Consumer is Producer" offered a new model for providing reliable energy to the customer where the customer themselves will produce energy and utilize it. It has claimed that this model will unlock the power market for the common people which will in result have a higher penetration of renewable energy in a national grid. However, no policy was given to show the way how this model may be implemented. The policy of power business of existing micro grid in Sandwip is based on two entity, the supplier and the customer. The supplier is liable for generation, distribution and also controlling the grid and the customers are liable only for consumption. There is no scope for the second entity to contribute in power generation and selling it. In this paper, A policy with several types of entity in the power market has been discussed in this research work. The policy also discusses the possible way to form the grid. The analyses according to the policy also show the possibilities to incorporate in the power market for the common people.

Keyword- Consumer, Common people, Power Market, Grid, Renewable Energy.

1. INTRODUCTION

"Consumer is Producer" is a model for providing reliable electricity by means of forming small and local electrical micro grid. The formation of the local grid in this model is different from other common micro grid. Source of energy, load, meter, controller and together is a unit which has been named as "Consumer Producer Unit" (CPU). A CPU may be operated either in grid connected mode or in isolated mode. Discretely created CPU may be interconnected to form a local grid where each CPU has the scope to share the generated electricity. The share of electricity means selling and buying the electricity. The local grids also may be interconnected and form a micro grid network by which the connection to large grid or national grid is possible [1].This model have a different grid expansion topology [2]. Though the source unit of CPU may be any types of sources, only solar Photo Voltaic (PV) panel is accounted as sources in this analysis.

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2. FORMATION POLICY OF MICROGRID

There may be several entities to form the proposed micro grid. The users may form a micro grid by interconnecting their own CPUs. However, this will create problem if there is no policy for interconnection in the local grid. Without any controlling entity over the grid, it will be more complicated to implement this scheme. Formation of the grid may be discussed by two stages. In the first stage, the backbone of the micro grid will be formed and at second stage, new CPU will be connected to the existing micro grid.

For a better explanation of the problem, it may be assumed that entity 1 will provide the scope of connectivity to the local micro grid for any new entity. Entity 1 will be responsible for the generation, grid related hardware and software support and the backup power. It will have its own power as well as buy power from entity 2. Entity 2 will be responsible for generation, backup (in some cases) and consumption. There may be a third type of entity namely, entity 3, which would be responsible for consumption only. For simplification, it is assumed that all of the power generated by entity 2 will now be sold to entity 1 with a price of B Tk. per unit and entity1 will sale this power to entity 2 or entity 3 with a price of S Tk. per unit. It is to be noted that entity 1 is a single body where as entity 2 or entity 3 are any CPU that is connected with the grid.

As renewable energy resources are intermittent sources, there must be a backup power or storage of energy to have a reliable and continuous power supply. If anyone of entity 2 wishes to stay disconnected from the grid and have to maintain smooth and reliable operation, he must have additional backup power and generation. Thus, it will cost 3 to 5 time more than the cost if connected with the grid. In this case, the return of initial capital will be delayed; actually, there will be no return, instead there will be a saving of cost of energy. Therefore, it is better to be connected with the grid, as it will reduce the initial investment and ensure the reliable and continuous supply of power.

For individual use, the day of autonomy is important. Day of autonomy is defined as the number of days in which the system will be able to operate without any interruption. It is kept as three days as standard for Solar Home System (SHS) program of Infrastructure Development Company Ltd (IDCOL)[3].This is done by storing the energy into deep cycle batteries. This costs a huge portion of the initial cost. Presently, market price of 100Wp panel is about 6,000Tk [4] and the battery used to store the energy of the panel for 3 days autonomy (150Ah-12V),which costs about 18,000Tk [4]. There are also costs for wiring, structure, controller and labor. By these ways, it will cost around 300Tk. per Wp to be installed. The market price of an SHS without inverter is about 40,0000Tk. Thus initial cost will be around 400Tk per Wp of solar panel [4].

In the case of grid connected mode, the cost is associated with only the panel, controller (here CPU), structure and labor. There is no cost for the storage. The approximate cost for the CPU may be 40,000Tk. for a 2KWp capacity panel. Including other costs such as labors, cable etc., the total cost to install a 2KWp capacity PV panel will be around 1,80,000Tk. In this way, it will cost around 90Tk. to install 1Wp of solar panel [5]. However, in this mode, cost for backup energy whether it is by means of battery or fuel based generator, will solely be borne by entity 1. It is to be noticed that the backup of the power may be accomplished by using battery only or by using fuel based generator with battery. For individual use, whether the backup energy is by means of battery (3 days autonomy needs a battery of large size) or by means of battery with fuel based generator, it will make the cost higher for entity 1 whereas, the cost will be lower for the grid connected mode as it is a large system.

On the other hand, the day autonomy for a grid is not three days rather the autonomy is for the period of sun set to sun rise (actually the period of zero production to start of production by the solar panels). For this reason, the size of the battery needed for the grid connected mode is just enough to store 40% of the total energy produced by the PV panels like the existing micro grid at Sandwip, Bangladesh [6]. Moreover, additional cost will be needed for the generator to run on the fuel. As a result, the cost associated for backup power or alternative energy for the grid connected mode would be much less than that for the individual mode. However, the running cost will increase slightly. Other cost associated with entity 1 is for the poles, cables, controllers for the distribution system.

3. BUILDING THE GRID BACKBONE

In this stage, entity 1 will fulfill all the requirements that have already been discussed for the grid backbone so that entity 2 / entity 3 can easily connect their CPUs when they wish. Power generated by entity 1 and entity 2 will be available in the grid to be consumed. A block diagram of the micro grid is shown in Fig. 1. It is assumed that initially demand as well as the number of connected CPUs will be less than that of a saturated grid. The total connected solar panel by entity 1 is SP_1 and by entity 2 is SP_2 .In this case, the total connected CPUs in the grid will be SP_T. Battery needed for this size of solar panel is B_T [6] whether it is served by entity 1 or by entity 2. For easy calculation, it is assumed that the total battery needed will be installed by entity 1 and fuel based generators which is needed for a reliable operation. The size of the backup generator will depend on the maximum demand of the system.

Presently, 40 customers are connected to the grid per km of distribution line [7]. For 200 users (types 2 and type 3), it needs 5km distribution line and 1km for interconnections of the line approximately. The number of distribution pole

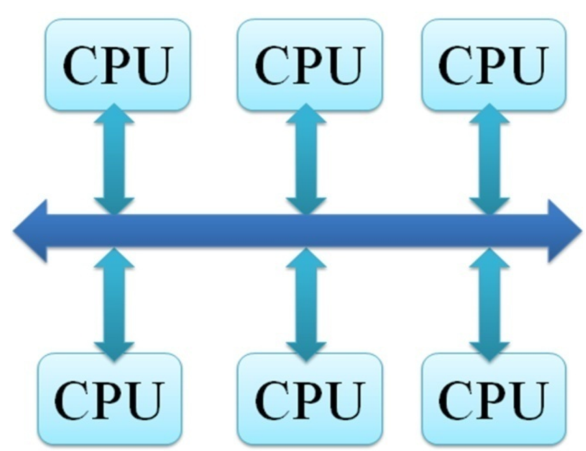

Fig. 1: Formation of micro grid in Consumer is Producer model

is assumed as around 60 (1 pole per 100 m). There are also cost involvements for central controllers and others equipment. Installation cost for entity 1 may be given by

$$C_{T1} = C_{P1} + C_B + C_{DL} + C_{DP} + C_{FG} + C_{CE} + C_o \quad (1)$$

The total Energy sale may be given by,

$$T_{S1} = (E_{P1} + E_{P2} - E_{PL} + E_{DG}) \times S \quad (2)$$

The total cost per year is given by,

$$T_{C1} = E_{P2} \times B + C_{DG} + C_{R1} \quad (3)$$

And the net profit per year is given by,

$$T_P = T_{S1} - T_{C1} \quad (4)$$

Where,
C_{P1} = Cost for solar panel
C_B = Cost for Battery backup
C_{DL} = Cost for Distribution lines
C_{DL} = Cost for Distribution poles
C_{FG} = Cost for fuel based generator
C_{CE} = Cost for Control equipment
C_O =other costs (labor, land transport etc.)
C_{T1} =Installation Cost.

E_{P1} = Usable energy from the Panels of entity 1 per year
E_{P2} = Total energy buy from entity 2 (Total 90KWp)
E_{PL} =Energy loss due to battery (Charging and discharging)
E_{DG} = Energy from DG (Assume 30% of Total
C_{R1} =Yearly Running Cost (employee + other maintenance cost)
S = Selling price of entity 1
B = Buying price of entity 1
T_{C1} =Total Cost.

4. INTERCONNECTION OF NEW CPU TO THE EXISTING GRID

The free space of rooftop a typical village is enough to install 2KWp of solar panel [1]. In this case, there will be no additional cost for the land. The costs are associated with the solar PV panel, CPU controller and others the installation cost for each entity 2 is given by

$$C_{T2} = C_{P2} + C_{CPU} + C_o \quad (5)$$

The total Energy sale may be expressed as

$$T_{S2} = E_{P2} \times B \quad (6)$$

Yearly Running Costs including employee and other maintenancies cost per year is given by,

$$T_{C2} = C_{R2} \quad (7)$$

And the net profit per year is given by,

$$T_{P2} = T_{S2} - T_{C2} \quad (8)$$

Where,
C_{P2} = Cost for solar panel by entity 2
C_{CPU} = Cost for CPU
C_o =other costs

5. COST APPROXIMATION OF THE POLICY ANALYSIS

Initial investment for entity 1 may be approximated as follows. Cost and calculation has been shown based on present market value and report of Sandwip 100K W_p micro grid. Bangladeshi Taka (Tk.) is used here as unit of money. In this approximation, 10% of total solar PV panel will be installed by entity 1. Rest 90% will be combined installed by all of entity 2. The analyses here are given for a 100K W_p solar PV micro grid, assuming B = 20Tk. and S = 25Tk.

5.1 Installation Cost of Entity 1

In this analysis, it is assumed that 90K W_p solar PV panel will be installed by 45 numbers of typical entity 2.Each of entity 2 will install 2K W_p of solar PV panel.A tentative cost analysis of 2K W_p of solar PV as follows,

Cost for the Panel (10KWp)= $10,000 \times 60 = 6,00,000$
Cost for battery (48000Ah, 12V) = 48, 00, 000
Cost for the distribution system (5km)= 5km $\times$ 80, 000 =4, 00, 000
Cost for the Distribution Pole (60)= $60 \times 10000 = 6,00,000$
Cost for Diesel 10KW Generator(3 unit)= 2, 00, 00 $\times$ 36, 00, 000
Cost for Control Equipment = 1, 00, 000
Approximate costs for Others(Land, labor, transport etc.)=1, 00, 000
Total Cost = 70, 00, 000

5.2 Per year calculation for entity1

National Renewable Energy Laboratory(NREL) is an international renowned institution for Renewable Energy analysis it offers an online analysis named PVwatt which is open to all. The following analysis is accomplished based on PVwatt analysis Usable energy generated from the Panel of entity 1(10K W_p),

$E_{P1} = 13,000$KWh [8]

Total energy buy from entity 2 (panel size 90KW$_p$,

$E_{P2} = 1,17,000$KWh [8]

Unit price of energy bought from entity 2, $B = 20Tk$.
Total cost of energy bought from entity 2, $C_{B2} = 23,40,000Tk$.
Total Energy from solar Panel generated by both entity $E_{PT} = E_{P1} + E_{P2} = 1,30,000KWh$.
Energy loss due to battery (Charging and discharging, $E_{PL} = 5,200KWh$
Energy used from the generation of Panel, $E_{PU} = E_{PT} - E_{PL} = 1,24,800KWh$
Energy from diesel generator (Assumed as 30% of Total, $E_{DG} = 53,485KWh$
Unit price of energy from diesel generator $d_c = 15Tk$.
Total cost of energy from diesel generator $C_{DG} = E_{DG} \times d_c = 8,02,285Tk$.
Total Energy sell, $E_{TS} = E_{PU} + E_{DG} = 1,78,285KWh$
Selling price of energy to entity 2 and entity 3, $S = 25$
Total selling price of energy to entity 2 and entity 3,
$T_S = E_{TS} \times S = 44,57,142Tk$.
Yearly Running Cost (employee + other cost) $C_R = 4,00,000Tk$.
Cost per year, $T_C = C_{B2} + C_{DG} + C_R = 35,42,000Tk$.
Net Profit per year, $T_P = T_S - T_C = 9,15,142Tk$.

5.3. Installation Cost of Entity 2

Cost of solar panel of 2K W_p, $C_{P1} = 2,000*60 = 1,20,000$
Approximate cost of CPU controller $C_{CPU} = 40,000$
Other costs $C_O = 20,000$
Total cost, $C_{T2} = 1,80,000$

5.4. Per year calculation for entity 2

National Renewable Energy Laboratory(NREL) is an international renowned institution for Renewable Energy analysis it offers an online analysis named PVwatt which is open to all. The following analysis is accomplished based on PVwatt analysis Usable energy from the 2K W_p solar panel per year = 2600KWh [8]
Selling price of per unit electricity, B = 20 52,000
Running cost 2% of initial cost= 3,200
Net Profit per year = 47,800

6. THE ANALYSIS AND RESULT

The policy has been discussed considering three types of entity. To analyze the policy, an algorithm has been developed in MAT-LAB programming environment. The payback period is an important factor for any business. The results of the analyses about the payback period for entity 1 and entity 2 are given here considering different selling price by each entity.

In these analyses, it is assumed that entity 1 will buy power from entity 2. Power generated by entity 1 and purchased from entity 2 will be sold to the customers whether they belong to entity 2 or entity 3. The next few figures show the return of initial investment for both entity 1 and entity 2 considering a fixed selling price of entity 1. Figure 2 shows the buying price of energy from entity 2 versus the simple payback period while the price of sales is 20Tk. The same are shown in Fig.3, Fig. 4, Fig. 5 for a selling price of 25Tk.,30Tk. and 35Tk. respectively.

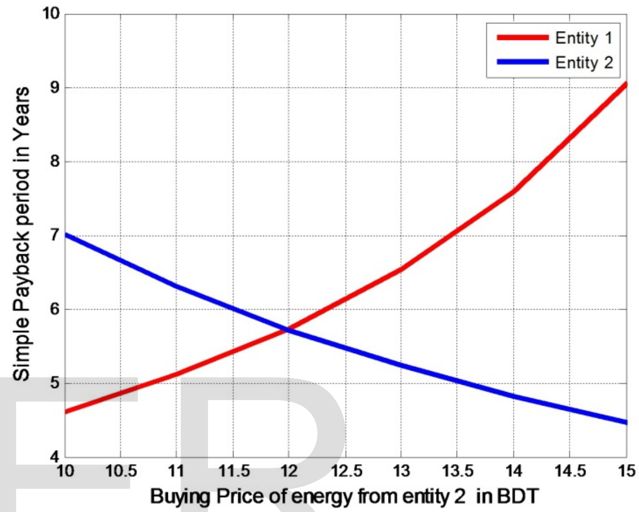

Fig. 2: Price of purchase of energy from entity 2 VS period of return of initial investment for both of entity 1 and entity2 while the selling price of energy by entity 1 is 20 Tk.

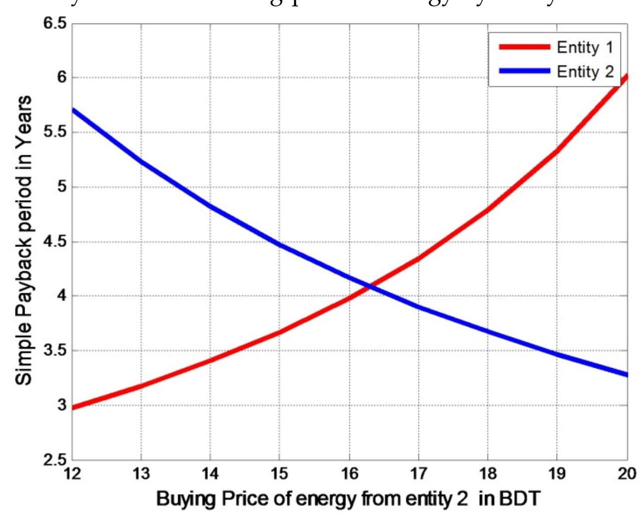

Fig. 3: Price of purchase of energy from entity 2 VS period of return of initial investment for both of entity 1 and entity2 while the selling price of energy by entity 1 is 25 Tk.

The next few figures show the payback period of the initial investment for both of entity 1 and entity 2 while the selling price of entity 2 is fixed. Figure 6 shows the price of energy sold by entity 1 to entity 2 or entity 3 in Bangladeshi Taka (BDT) versus simple payback period for

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both entities in years. Figure 7, Fig. 8 and Fig.9 show the same for energy price of Tk. 15, Tk. 20 and Tk. 25 respectively. It is to be noted that

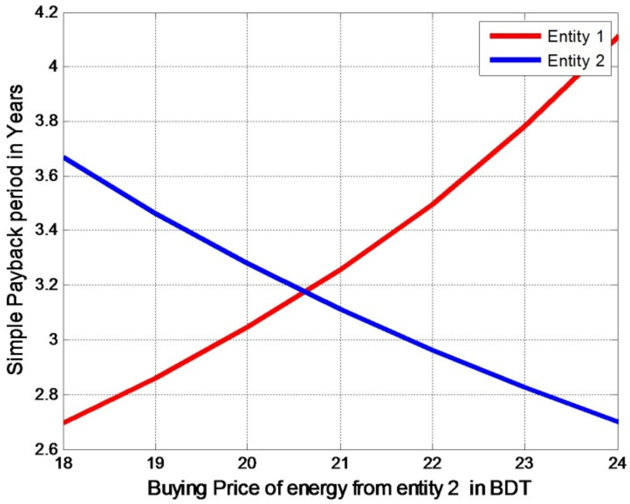

Fig. 4: Price of purchase of energy from entity 2 VS period of return of initial investment for both of entity 1 and entity2 while the selling price of energy by entity 1 is 30 Tk.

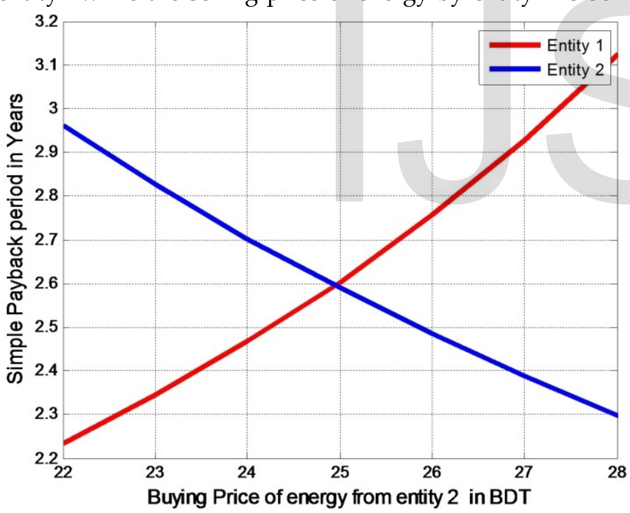

Fig. 5: Price of purchase of energy from entity 2 VS period of return of initial investment for both of entity 1 and entity2 while the selling price of energy by entity 1 is 35 Tk.

as the selling price of energy by entity 2 is not changed, their payback period is not changing with the change of that of entity 1. Presently, the customers of the 100KWp Solar diesel Hybrid Micro grid, Sandwip are paying 30Tk. per unit of electricity. The analyses from the above figures show that, the payback period of both entities will be around 4 years keeping the price of electricity within a reasonable range. However, entity1 and entity 2 may have different payback period depending on the selling and purchasing price of electricity.

These could be obtained from the relevant Figures (Fig.2 to Fig. 8).

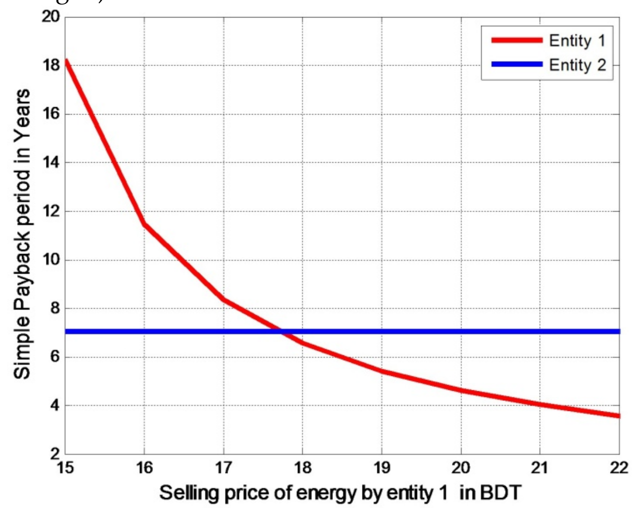

Fig. 6: Payback period of the initial investment for both of entity 1 and entity 2 while the selling price of entity 2 is 10Tk.

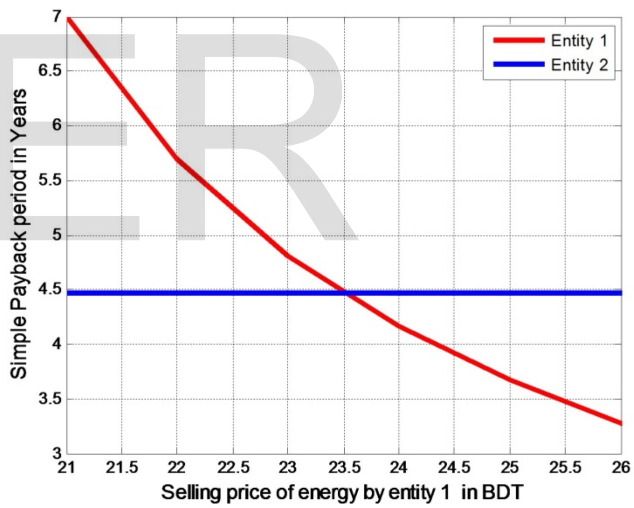

Fig. 7: Payback period of the initial investment for both of entity 1 and entity 2 while the selling price of entity 2 is 15Tk.

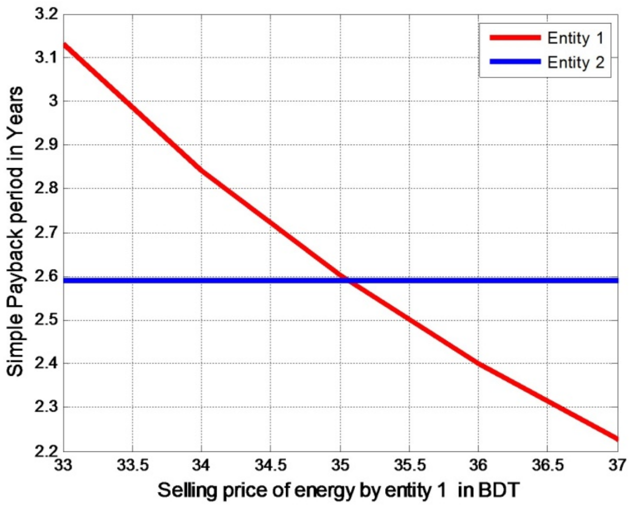

Fig. 8: Payback period of the initial investment for both of entity 1 and entity 2 while the selling price of entity2 is 25Tk.

7. CONCLUSION

The model "Consumer is Producer" can be used as an alternative and supplement to the traditional power systems. The policy discussed in this research work to implement the model shows an way to engage common people into the power market. As the scale of the unit is assumed to be smaller than the unit of a traditional large renewable energy micro grid, but larger than the unit of a solar home system, people having lower income may be interested to involve into power business. Due to its easy installation and maintenance, it will require less installation time and thus would allow a quicker growth of penetration of renewable energy into national energy production. In this way, this inrush of people to engage the power market will unlock the energy business for the common people. This will penetrate a significant percentage of renewable energy into the national generation. Hence, the rate of global warming and green house gas effect will be decreased which is prime concern of present world. Better and more effective policy may be offered from the government like IDCOL's SHS program to promote this model.

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