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Analysis of smart grid with 132/33 KV sub-transmission line in rural power system of Bangladesh

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Abstract: "Smart Grid" is a modern concept which refers to the conversion of the mainstream or typical electric power grid to a modern power grid. This new conversion is a foreseeable solution to the power system problems of the modern century. Rejuvenation of the current electric power distribution system is an important step to implement the Smart Grid technology. So, distribution system engineers should be acquainted with the knowledge of Smart Distribution System. Also the customers should acknowledge the benefits that they will be enjoying from this modernized power system. There are power crisis everywhere in the world, besides there is system loss in the existing power system. It is happening in Bangladesh also. To reduce power crisis renewable source of energy like solar energy, wind energy, raw coal energy may be used. But the quantity of electricity produced by this renewable energy source is low and several kilowatts range. This electricity is utilized by smart grid which is hard for usual power grid system. For this reason we need hybrid ac/dc smart control grid system. In this report models using Wind-mil Software is proposed for reducing system loss and also incorporate smart metering so that the power flow can reach easily to the consumers. Smart grid also helps sole proprietor and individual business man to sell their little amount of electricity to the grid which they produce by their own entrepreneurship through smart meter. Line loss and regulated voltage, regulator and capacitor are also inserted here to reduce the loss and make the effective and efficient power supply to the consumer. This metering is also centrally controlled and works over a huge area. At present developing country should develop this system.

Keywords: Controllable Loads, Wind Turbine Generator, Smart Grid, Smart Metering, Windmill Software

1. Introduction

Energy generation is one of the key factors in driving the socio-economic growth of any country. In Bangladesh, increasing demands for energy has already exceeded the capacity from existing plants from conventional sources of energy. Thus access to electricity is very limited where Per capita energy consumption is about 237 KOE. There are still lots of area where there is no supply of electricity. Attention is being focused on renewable energy sources and to harness electricity from them to meet the national energy demand. In Bangladesh solar photovoltaic (PV) systems are being widely deployed in rural areas and large scale coverage in rural areas with renewable energy sources is being actively considered with mini-grid structure. Such a grid system can implement smart grid techniques by the efficient management of the power grid systems in many countries around the globe. A Smart Grid is a form of electricity network using digital technology. A smart grid delivers electricity from suppliers to consumers using two-way digital communications to control appliances at consumers' homes; this could save energy, reduce costs and increase reliability and transparency if the risks inherent in executing massive information technology projects are avoided. The "Smart Grid" is envisioned to overlay the ordinary electrical grid with information and net metering system, this system includes smart meters. Smart grids are being promoted by many governments as a way of addressing energy independence, global warming and emergency resilience issues. The function of an Electrical grid is not a single entity but an aggregate of multiple networks and multiple power generation companies with multiple operators employing varying levels of communication and coordination, most of which is manually controlled. Smart grids increase the connectivity, automation and coordination between these suppliers, consumers and networks that perform either long distance transmission or local distribution task.

Transmissions networks move electricity in bulk over medium to long distances, are actively managed, and generally operate from 345kV to 800kV over AC and DC lines. Local networks traditionally moved power in one direction, "distributing" the bulk power to consumers and businesses via lines operating at 132kV and lower. This paradigm is changing as businesses and homes begin generating more wind and solar electricity, enabling them to sell surplus energy back to their utilities. Modernization is necessary for energy consumption efficiency, real time management of power flows and to provide the bi-directional metering needed to compensate local producers of power. Power demand in isolated islands has been increasing rapidly. Diesel generators fueled by fossil fuels mostly supply the power for this power demand. For greenhouse gas reduction and oil substitution, introduction of renewable energies such as photovoltaic and wind energy is important. Renewable power resources are safe, clean, and abundant in nature. However, due to the power fluctuation of renewable energy sources, voltage and frequency deviations are occurred in island power systems whose ability to maintain stable supply–demand balance is low. Therefore, it is necessary to control the system frequency and voltage at the supply side. At the supply side, installation of storage equipment and pitch angle control of a wind generator has been proposed for control of the distribution power system. However, the installation of storage equipment that needs large storage capacity and the cost of maintenance for battery degradation are not expected. Hence, in case of using the renewable energy plants connected to power system, supply-side control has limitations. Therefore, mutual cooperation control with the demand side is required because it is difficult to maintain the power quality by only the supply-side control. From this viewpoint, a smart grid, which maintains stable supply–demand balance by monitoring the power information of the demand side, is necessary. Smart grids provide an excellent opportunity to manage power quality better and reduce harmonic distortions of the power networks. The impact on power quality is taken into consideration from the viewpoint of a generator side, a grid side, and a demand side management. It is expected that smart technologies will lead to reduced investment in primary equipment and it will increase higher availability of power supply.

2. Present Scenario of Transmission and Distribution System of Bangladesh Electrical Power

Because of major reforms, restructuring and corporatization process of Bangladesh power sector, a number of distribution entities were formed with the objective of bringing commercial environment including increase of efficiency, accountability and dynamism with the aim of reaching electricity to all citizens by 2021. In order to increase and improve power generation and customer service with an aim to bring a greater mass under electrification, major integrated power distribution programs have been undertaken. Presently the following five organizations are responsible for the distribution of power:

1. Bangladesh Power Development Board (BPDB)
2. Rural Electrification Board (REB)
3. Dhaka Power Distribution Company (DPDC)
4. Dhaka Electric Supply Company (DESCO)
5. West Zone Power Distribution Company (WZPDC)

Table 1. *Overall scenario of distribution line in Bangladesh*

Total Distribution Lines	278,000 KM
Total Consumers	12.5 million
Irrigation Consumer	2.77 Lac
Access to electricity	50%
Distribution Loss	12.75%
Accounts Receivable	2.22 Equivalent months

At present the government has taken measures to reduce system loss and increase customer satisfaction. Under this project 409 interface meters have been installed at all generating stations throughout the country and Dhaka distribution zone and transmission network at 230KV, 132KV and 33KV level. All the meters are connected with the main server which is located at Bidyut Bhaban (13th floor), Dhaka, Bangladesh. Energy inflow/outflow, demand, voltage, current, power factor, meter tempering etc. may be known from the main server. BPDB, REB, DPDC, DESCO and WZPDC have individual workstation and can read data at some level. The interface meters have been used as billing meters. This will be extremely beneficial for the energy auditing system. Operator's performance will also be enhanced significantly and accountability and transparency will be established in the energy auditing system.

The government has crossed some prominent hurdles in this challenging field. But Bangladesh still faces power shortages and that is the reason the GoB has set a target for providing electricity to all citizens by 2021. This electrification target is unlikely to be met by grid expansion alone, as rest of the populations live in remote areas which are far away from existing grid line and sometimes isolated from the main land. Considering this over arching goal, the government has identified private sector participation as an important requirement. Since power system development is highly capital- intensive, the government encourages private sector investment to implement RAPSS. Under the RAPSS concept, private investor will be given an area (the RAPSS Area) for the development, operation and maintenance of the electricity distribution and retail supply system, including generation as a utility for a period of 20 years. The government has taken initiatives to establish solar mini-grid for remote off-grid area under RAPSS where grid expansion is not planned for the next 15 to 20 years.

3. Smart Grid platform for Bangladesh

The power system in Bangladesh is very complex and quite aged with lots of lacking. But, there are many scopes to convert the power grid of Bangladesh to the smart grid. To address the power crisis and other problems, it is the high time to initiate the plans to form grids which are more smart, receptive and flexible than present power grids. In Bangladesh, not only by integrated communication techniques but also by increasing the usage of renewable resources the implementation of smart grid technology can be achieved. In prospective to the socio-economic condition of Bangladesh; smart grid will enable consumer empowerment to manage their energy usage and financial savings. In recent days, an interest is increasing rapidly about the small-scaled grid system based on several tens of Photovoltaic power generation. Such a grid system, which is called as micro grid, has advantages to increase an operational efficiency and economics when it is connected to grid or supply a secured electric power at islands, mountains and remote areas without connecting grid. The micro grid is divided into ac micro grid and dc micro grid, which is classified by whether, distributed sources and loads are connected on the basis of ac or dc grid. ac micro grid has a benefit to utilize existing ac grid technologies, protections and standards but stability and requirement of reactive power are the inherent demerits of it. On the other hand, dc micro grid has no such demerits of ac micro grid and assures reliable implementation of environment-friendly distributed generation sources.

4. Proposed Smart Grid

Our proposed smart grid model consists of a smart model of the Khulna region power system. The model includes different power stations there. It also included the simulated the output of this virtual designed smart power system. In our proposed system we tried to apply the local power system in our design and then simulated and also debugged the design that we find a case. We tried to find good efficiency and reduce the power loss. We also given the practical data (from goalpar110 MW power plant, PGCB Khulna South and also from nearest substations) as input.

4.1. System Configuration

In our main system configuration of figure 1, we have drawn a model of small area smart grid model. We put all the transformer, transmission lines, substations, generation power plant also and we simulated our design with actual data and we can increase performance and efficiency Power system of least developed country is very poor in performance and classical, we tried to figure out something better than existing model. The WTG (Wind Turbine Generator) has no gear. It is rated several like 1 or 2-MW generator. Permanent Magnet Synchronous Generator (PMSG) generally used in WTG. Its structure is not complex and performs well with high efficiency.

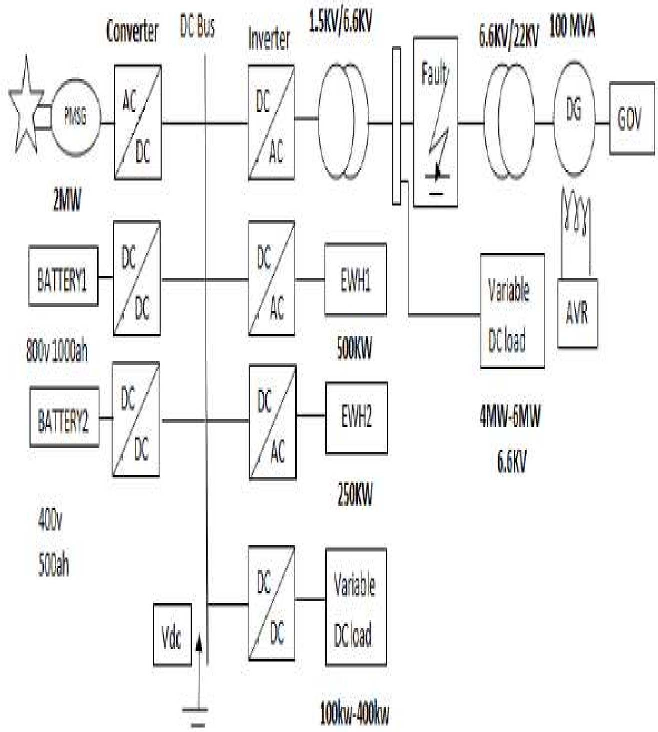

Figure 1. *DC smart grid system*

It is predicted that the future wind turbine generator will be PMSG based. Generator side used a convertor in this dc model of smart grid, also a grid-side inverter used here. Various loads like chargeable batteries and electric heaters are connected to this grid. Total system is attached to a diesel generator and variable ac load via the grid side inverter and the transformer. The output power of Wind turbine is given to the PMSG. To get optimal power a pulse width modulated converter is used as a controller of PMSG. DC distribution system is used to supply the PMSG's output power to consumer. Rest of the power is sent to the ac load in assistant with a grid-side inverter.

Rotational side converter effects on the rotational speed of the PMSG effects The PMSG model is explained in. A generator side converter effects on the rotational speed of the PMSG. This is for getting variation of speed. Also for maximum power operation and maximum power point tracking (MPPT) control. This makes the system torque under control. For observing the speed control we the speed control of the PMSG are sensed on a dynamic frame. Here the rotational speed error is given as input of the controller of speed. From the controller the axis stator current is tuned automatically. Usually, the salient pole type synchronous machine is controls the d-axis stator current and the reference are expressed by the following equation [1]:

$$i_{1d}^{*} = \frac{\emptyset_f}{2(L_d - L_q)} - \sqrt{\frac{{\emptyset_f}^2}{4(L_d - L_q)^2} + i_{1q}^2} \quad 1$$

4.2. Grid-Side Inverter & Controllable Load

For frequency and voltage controls grid-side inverter is preferable. The control system the grid-side inverter is mainly done by controlling axis current. Current and voltage can be controlled by the axis current. We set the frequency to 60 Hz and the voltage to 6.6 kV. The dc bus voltage is controlled by the voltage control of the controllable loads. EWH and battery are used as controllable loads. The decentralized EWH model for each house connected to the dc grid. The EWH is modeled as a current source and each EWH is controlled to consume power within the rated range. The temperature of accumulated water of EWH is controlled by feedback control with an integral of the power consumption. In this control system, the dc bus voltage fluctuation is suppressed by the droop control, the power consumption. Command is decided by the droop coefficient and the controlled variable produced by controller of water temperature. The design of the droop coefficient is explained in the next section.

4.3. System Design

In this section we have some interface that is user operated. There have commands like add device, change feed, back feed, split, disc (disconnect), connect, rotate, move, devices, zoom to fit, zoom in, zoom out, calculate analysis etc. with this command one has to work with Wind-mil software. In the system design part we have designed a smart grid system with respect to our country and we have taken as a reference Khulna Central power grid. In this design we included a source, three transformer, overhead lines, and five nodes which is different substation of the Khulna Central Grid. As we worked in student version we had to use limited components. If we get the main version then we will do the more sophisticated smart grid design. For grid setting we double clicked on the source of the design and then a circuit element editor appeared and then we clicked to the navigator input the data and at last push on apply change tab. By clicking the impedance code min & max in the editor in the right box, we selected Khulna Central from the Equipment list and clicking ok we came out of the editor

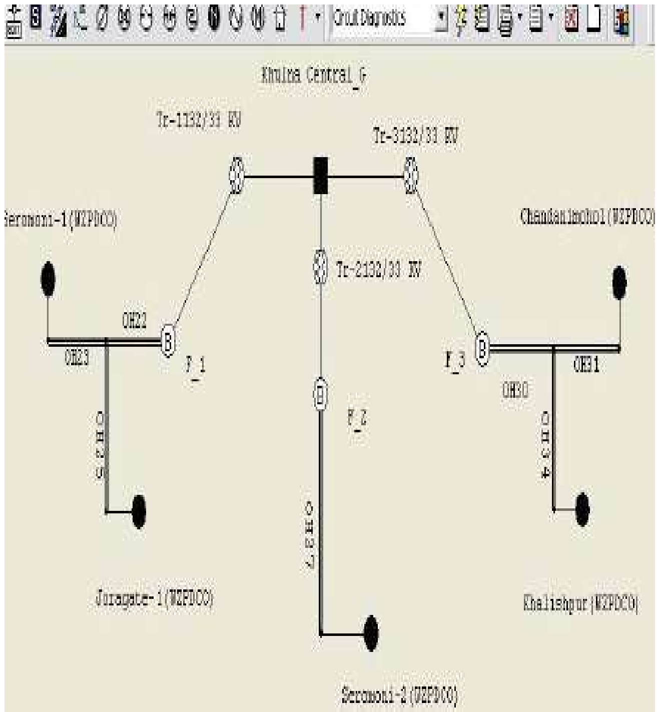

Figure 2. *Smart grid system design for Khulna local sub-station area, Bangladesh*

The analysis starts with Circuit Diagnosis. At first, we put circuit diagnosis and then recalculate analysis command is pressed. Then we found a new window showing errors and warnings.

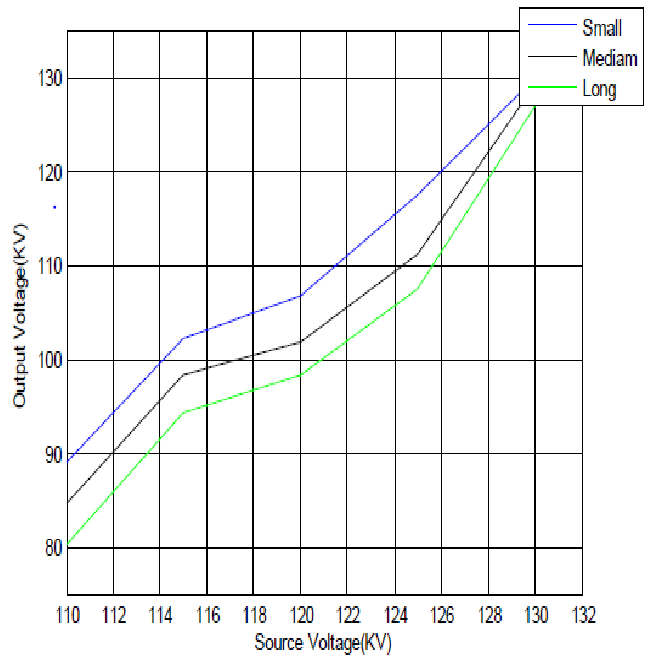

Figure 3. *Source Voltage Vs Output Voltage in our smart grid system. (All voltage values are assumed comparing with the data of PGCB Khulna South substation).*

Table 2. *Output voltage of substation with connection of capacitor and without connection of capacitor*

Source Voltage(KV)	Output Voltage (KV) for S-6000KW, M-6000 KW, L-8000KW					
	Without Capacitor			With Capacitor		
	S	M	L	S	M	L
132	130.1	130	124	130	131	125.7
125	116.59	123.01	118	116	123.9	119
120	107.2	118	109.7	107	119	110.16
115	97.99	112.5	100	98.3	114	100
110	89.05	101.9	90	89.87	103.05	90.34

5. Some Aspects of DC Micro Grid over AC Micro Grid for Bangladesh

Since Bangladesh is a densely populated country; a high quality of power is required for such agricultural dependable society and dc grid can assure it. For example, if a blackout or voltage sag occurs in a bulk dc and ac hybrid power system, most inverters might be tripped. So, it is difficult for ac micro grids to keep a super high quality power supplying continuously in islanding operation. A significant part of the system is transferred to the consumer's premises; reducing the initial cost of the power company and overall maintenance of the system. Since the cost of the battery and inverter is taken away from the power company, the overall maintenance is simplified so as the cost of energy (can be as much as 40%). In addition to this small scale rural industries like irrigation, rice husk can use the high voltage (240 V dc) directly without using dc-dc converter. The ac micro grid has some inherent problems such as synchronization, stability, need for reactive power while dc grid system is immune to those. Moreover, it is to be mentioned that the dc micro grids can be turned into a viable proposition due to its low cost over ac micro grids since the energy cost comparison between an ac and dc grid has been shown in previous research work.

6. Conclusion

At present smart grid is being developed according to practical hypothesis. This will make the world more economic and people can get the best output through it. The extra energy of the total system will also be managed by this grid system. Here we tried to design a small interconnected smart grid. Country like Bangladesh should implement smart grid in their transmission and distribution system to utilize the generated power. As people of Bangladesh are suffering for power shortage, government should take immediate steps to generate more electricity as well take necessary steps for proper distribution of the generated power.

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References

[1] Duic N. & Carvalho M. G. (2004) "Increasing renewable energy sources in island energy supply: case study portosanto," *RENEWABLE SUSTAINABLE ENERGY*, VOL. 8, PP. 383–399.

[2] J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.

[3] Senjyu T., Sakamoto R., Kaneko T., Yona A. & Funabashi T. (2009) "OUTPUT POWER LEVELING OF WIND FARM USING PITCH-ANGLE CONTROL WITH FUZZY NEURAL NETWORK," *ELECTRIC POWER COMPON. SYST.*, VOL. 36, NO. 10, PP. 1048–1066.

[4] Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, "Electron spectroscopy studies on magneto-optical media and plastic substrate interface," IEEE Transl. J. Magn. Japan, vol. 2, pp. 740–741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].

[5] Johnson A. P. (2010), "The History of the Smart grid evolution at southern California edision," Presented at the IEEE pes innovative smart grid technologies conf., GAITHERSBURG, MD. SOOD V. K., FISCHER D., EKLUND J. M., AND BROWN T. (2009) "DEVELOPING A COMMUNICATION INFRASTRUCTURE FOR THE SMART GRID," IN *PROC. ELECTR. POWER ENERGY CONF.*, PP. 1–7.

[6] http://www.powerdivision.gov.bd/user/brec1/43/1