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Design of Hybrid Mini Grid for Off-Grid Telecommunication Equipment in Bangladesh

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ABSTRACT

Photovoltaic (PV) Smart Grid systems can make a positive contribution to the sustainability of rural communities in developing countries that do not have access to electricity grid. Integration of solar photovoltaic system with diesel generator for remote and rural areas would assist in expanding the electricity access in the tropical region. The Smart Grid approach performance in terms of technical and economic aspects and their prospects has been presented in this paper.

Introduction

Technology roadmap is an important tool for collaborative technology planning and coordination actions for corporations, industry, civil society, universities as well as for all policy makers.

A technology road map matches short-term and long-term goals with specific technology solutions to meet identified plans. The technology roadmap process consists of three phases preliminary activity, development of the technology roadmap and follow up activity. It also provides information to make better technology investment decisions by identifying critical technologies, technology gaps and ways to leverage R&D investments. It can also be used as a marketing tool. Bangladesh is situated between 200 34' and 260 38' north latitude and between 880 01'and 920 41' east longitude with an area of 147,500 Sq. Km, which is an ideal location for solar energy utilization. Daily solar radiation varies between 4 and6.5kWh/m2 [1,2].Solar PV technology is an important emerging option for electricity generation. So, densely populated tropical country like Bangladesh could be electrified by PV Super Smart grid system using the inexhaustible and pollution free solar energy without using any novel technologies. This papers analyses and discuss the PV technology status and prospects in Bangladesh. Despite the large potential for development of renewable energy sources in Bangladesh, currently their contribution to electricity generation remains insignificant. We show in this paper that the present situation of PV technology in Bangladesh. We show in this paper that even a densely populated country like Bangladesh can attain a high standard of living by a proper utilization of solar energy.

Present Scenario of Transmission & Distribution System Bangladesh

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: Information of current distribution system of 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.

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But Bangladesh still faces power shortages and that is the reason the government of Bangladesh 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.

Smart Grid & It's Platform For Bangladesh

The European regulators 'group for electricity and gas (ERGEG) defines Smart Grids as follows: ''Smart Grid is an electricity network that can cost efficiently integrate the behavior and actions of all users connected to it –generators, consumers and those that do both – in order to ensure an economically efficient, sustainable power system with low losses and high levels of quality and security of supply and safety''.

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.

Energy Demand & Scenario of Bangladesh

In 1994, the total electrical energy demand was 9.63 TW h and had increased to 27.6 TW h in 2009 [5,6]. Based on the projections of Refs and [7], this energy demand will increase to 102.42 TW h and 100.08 TW h in 2025, respectively. The Long-range Energy Alternatives Planning (LEAP) tool was examined to form demand scenarios according to the trend of gross domestic product (GDP) growth rates (5.5%, 6.8% and 8%) and the nature of the energy sector itself, and taking into consideration broader factors, e.g., population, households, urbanization and other influencing factors for the time span 2005-2035 [8]. It is worth mentioning here that the actual GDP growth rate in Bangladesh is neither low nor high and therefore, in this study, the demand projection is based on a GDP growth rate of 6.8%. It can be found that a fully utilized Base Transceiver Station (BTS) with 5 operators may require 8 KW of electrical power from either the utility grid or a diesel generator. For rural installations, the peak load is smaller, but on the other hand, the effective numbers of operation on autonomous power is larger, in many cases 24 hours a day. Obviously, the local power grid is the first choice as power source, but with backup power generators as part of the solution. For site planning purposes, the backup generator set must handle the entire load of BTS including air conditioning as well as unavoidable power losses. For diesel fuel consumption calculation, the concerning issue is the average number of hours of operation, add margin for cold starts and certain fuel loss, maintenance cost and operation cost related not only to site power requirements but also contamination, pilferage and various other reasons. Study has assumed that an effective operating time is 7 hours out of 24 for an urban installation with an effective hourly fuel consumption rate of 3 liter per hour. Approximately 30000 BTS are running in Bangladesh and at rural areas almost 3500 BTS are working. So if we calculate average 7 hours power backup in rural area then almost (365*7*3500*3) = 26827500 liter diesel. Now per liter diesel price is 91 BDT. In that case, price will be 2441302500 BDT which is equivalent to 30139537 USD (1 USD~81 BDT). Country like Bangladesh, it is a huge cost to bear.

The highly promoted solar PV-system is too much expensive and the battery needs to change which add up to the maintenance cost. Alteration of existing trend of stand-alone solar system is evident in near future as several projects to connect multiple users with mini-grid are in operation. Hybrid mini-grid is less costly, easy to maintain and operate, and flexible for future extension. Apart from BTS, critical infrastructures like hospitals, banks can get reliable energy access if hybrid mini-grid is put into action. The first and only hybrid wind-PV system, a 10 kW Wind-Solar Hybrid generation unit, is established by Sustainable Rural Energy under Local Government Engineering Department (LGED), financed by UNDP and MoEF in Saint Martin Island. [6] But the generation unit failed due to design flaw, construction error and lack of maintenance. Although the pilot project wasn't subjected to any community rather it was constructed for demonstration and to understand the future potential of PV-Wind hybrid system. However, the project itself succeeds to demonstrate the prospect of solar-wind hybrid model in the south-eastern part of Bangladesh. In remote areas of Bangladesh, off-grid technologies in combination with sustainable financial management promise environment-friendly access to electricity at a lower cost than conventional technologies. For many locations in Bangladesh it is found that hybrid generation using PV or wind along with diesel is cost effective. But the maintenance cost for diesel integrated system tends higher.

While designing a hybrid mini-grid, a lot of issues need to be considered both prior and after the establishment of the system. A cost-efficient design of a hybrid power system must precisely bridge between production capacity and local demand. Oversize system increases the already high capital costs, producing a surplus of electricity whereas under-size capacity results in unavailability of power, higher stress on the components and resulting dissatisfaction among end-users, which can lead to the failure of the project. In order to install the correct production capacity, precise estimates of demand are

needed. In the simplest calculation, the demand is equal to the number of BTS multiplied by the estimated average use of electricity per BTS. However, this approach is not accurate as the margin of error is quite large for a large number of BTS. Instead, it is better to aggregate the estimated electricity demand of each BTS.

PV Goals, Strategies & Market Development

The increasing efficiency, lowering cost and minimal pollution are the boons of the photovoltaic systems that have led to a wide range of their application. Photovoltaic's as one of the inexhaustible renewable energy resources today have a wide range of application, starting from very small units for the supply of small electric consumers going to large PV power plants with MW power. After the experience of dozens of years of application, grid-connected photovoltaic systems and their components today have higher efficiencies, are relatively reliable but still are quite costly. Most technical and non-technical barriers could be overcome in Germany during recent decades and private house owners as well as small and large enterprises are free to transfer sunlight to electricity, which either can be consumed by the plant owners or can be sold to the public grid.

Photovoltaic (PV) hybrid systems can make a positive contribution to the sustainability of rural communities in developing countries that do not have access to electricity grid. Integration of solar photovoltaic system with diesel generator for remote and rural areas would assist in expanding the electricity access in the tropical region. A survey of PV hybrid system in Bangladesh during the last decade regarding to status of technology, performance in terms of technical and economic aspects and their prospects has been presented in this paper. If Bangladesh is serious about reaching its target to keep global mean temperature it must strive for a 100% renewable electricity system by 2050. The Smart Grid approach combines what is often perceived as two exclusive alternatives: wide area power generation and de-centralized power generation. We argue that by combining these, in fact, complementary measures, it is possible to address the crucial issue of renewable generation fluctuating supplying a comprehensive as well as in a technologically and economically viable manner. Thus, the Smart Grid simultaneously can contribute to energy security, climate security, social security, and national security.

Currently, Bangladesh Government is providing new ways in energy policy to enhance and accelerate the development of low-power photovoltaic generation facilities for self-consumption by introducing energy policies for feed-in payments of surplus electricity. Such facilities are an example of distributed electrical generation with important benefits for the environment and the rest of the electrical system because, when properly managed, they can help improve the system's stability and reduce overall losses. By analyzing household demand and solar photovoltaic energy resources, the profitability of such facilities is considered in this article, taking into account the technical and economic impact of storage systems and proposing models for feed-in payments of surplus electricity, in an attempt to assess whether this method of electricity generation versus the method of conventionally supplied power from a grid at a regulated tariff can rival each other economically, in terms of parity. Now the The present share of Renewable Energy is about 0.8%. However, Renewable Energy would have a significant contribution in the global climate change scenario. According to the Renewable Energy Policy approved in 2008, the Government is committed to facilitate both public and private sector investment in renewable energy projects to substitute indigenous non- renewable energy supplies and scale up contributions of existing renewable energy based electricity productions.

We need to know the technological development and research efforts in the field of PV among developed countries. The European Communities (EC) objective is to expand the use of grid connected pv systems in the electricity sector with a meaningful and growing penetration by pv in Europe by 2030, and a significant penetration in non - grid markets by 2020. There research priorities are strongly oriented towards cost reduction of electricity produced from solar cell, on the other hand japans plan to have a working space solar power system in orbit by 2030 and also planning to establish solar farms which can focus sunlight a top towers with stirling engines and other generators In Bangladesh present status is stated below -

Ongoing Projects

- BPDB is going to install 650 KWp (400 kW load) Solar Mini Grid Power Plant at remote Haor area of Sulla Upazila in Sunamgonj district under Climate Change Trust Fund (CCTF) on turnkey basis. Avoid combining SI and CGS units, such as current in amperes and magnetic field in oersteds. This often leads to confusion because equations do not balance dimensionally. If you must use mixed units, clearly state the units for each quantity that you use in an equation.
- 8 MW Grid Connected Solar PV Power Plant at Kaptai Hydro Power Station, BPDB, Rangamati on turnkey basis.
- 3 MW Grid Connected Solar PV Power Plant at Sharishabari, Jamalpur on IPP basis.
- Solar Street Lighting Projects in seven (7) City Corporations of the country.
- BPDB is installing Solar Roof Top Systems in all BPDB offices across the country to run the light and fan load. More than 140 kWp solar PV systems have already been installed and installations of 485 kWp solar PV systems are under planning/implementing stages.

Projects Under Planning

- BPDB has planned to install Grid Connected Solar PV Power Plant (3 MW Grid Connected Solar Power Plant at Rajabarihat, Rajshahi & 1 MW Grid Connected Solar Power Plant at Regional Training Centre (RTC), Rajshahi) on IPP basis.
- 500KW Solar Mini Grid Power Plant on turnkey basis under Climate Change Trust Fund (CCTF) at Swandip, Chittagong & Thanchi of Bandarban district.
- Solar Park Projects on IPP/PPP basis of 40-45 MW Solar Park Project adjacent to Bangabandhu Bridge,Tangail and Sirajgonj area.
- 2-3 MW Solar Park Project adjacent to PGCB Grid Sub-station compound, Ishwardi.
- 20 MW Solar Park Project adjacent to new Dharala Bridge, Kurigram

Global Market Outlook

Statistics shows that solar photovoltaic (PV) capacity was added in more than 100 countries during 2010, ensuring that PV remained the world's fastest growing power-generation technology. Within the last decade, Japan has taken over global leadership from the United States in terms of installed capacity, market power and industrial knowledge in the field of photovoltaic's. Globally, PV systems connected to the grid increased from 16.6 GW in 2010 to 27.7 GW in 2011. Increasing the PV momentum by adding additional markets of important growth can be considered the single most important achievement on the continued growth track of world-wide PV development. PV is now, after hydro and wind power, the third

most important renewable energy in terms globally installed capacity.

Policies & Cost

The road map assumes that cost reductions for future PV systems continue along the historic PV experience curve. PV module costs have decreased in the past at a learning rate of 15% to 22% and have seen a corresponding reduction in total system costs for every doubling of cumulative installed capacity. The primary PV economic goal is to reduce turnkey system prices and electricity generation costs by more two thirds by 2030. Turnkey system prices are expected to drop by 70% in 2030, with a major price reduction (over 50%) already by 2020. Lastly in the best case will lead to long term levelised generation cost lower than USD 50/MWh.

Policy of Government is to use photovoltaic for reducing the climate change for decreasing the CO2 emission. Bangladesh power sector totally depend on gas. Since gas reservation is not satisfactory and statistics shows that it will not continue more than 10 years so it is expected country will totally depend on renewable energy especially in solar energy. Reports show that about 50174 MW can be generated from solar PV which is almost 10 times more than present demand. Another policy is to reducing PV cost with improving products and components we can follow the below mentioned notes-

- Create a policy framework for market deployment.
- Improving products and components. Financing models and training and education to foster market facilitation and transformation.
- Supporting continuing technology development and sustained R&D efforts to advance the cost and efficiency improvements.
- Improving international collaboration to allow for accelerated learning and knowledge transfer to emerging and developing countries.

Conclusion

Photovoltaic (PV) smart grid systems can make a positive contribution to the sustainability of rural communities in developing countries that do not have access to electricity grid. Integration of solar photovoltaic system with diesel generator for remote and rural areas would assist in expanding the electricity access in the tropical region. A survey of PV smart grid systems in Bangladesh during the last decade regarding to status of technology, performance in terms of technical and economic aspects, and their prospects has been presented in this paper. A review of the overall energy production and utilization as well as the system performance of PV smart grid system in Bangladesh indicates the promising potential of such systems in the future.

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