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Operational Experience in Sustainable Decentralized Distributed Generation (DDG) Technologies in Energy Space-Status Review

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Abstract—*this paper attempts to highlight the role of engineering in creating a sustainable future for humanity by providing an overview of the various initiatives taken at Tata Power. Amongst the various innovative projects completed at Tata Power, some of the projects will help in community development. These projects include using technologies related to solar, hydro, micro grid, gasification. The technologies have been demonstrated as a viable solution such as DC Micro-grid, floating solar plant, hydro kinetic turbine and biomass gasification system which are modular and scalable. The paper also discusses the problem faced during operation and mitigation measure adopted.*

Keywords*: Sustainable, DDG, Energy, Solar, Hydrokinetic*

1. INTRODUCTION

A United Nations report [1] defines sustainable development as development that meets the needs of the present without compromising the ability of the future generations to meet their own needs. This involves conserving the environment and developing new energy technologies for sustainable development and resource conservation. This can be achieved by efficient engineering and by adopting cost effective, innovative as well as environment friendly technologies. Tata Power has been a pioneer in developing & adopting eco-friendly technologies. Tata Power has developed Decentralized Distributed Generation (DDG) solution to utilize the existing resource optimally and improving rural community lives. The decentralization of technology helps in faster deployment. Tata Power is committed to increase its sustainability initiative as 'Sustainability' is one of its pillars and community development has always been on the forefront of Tata Power's initiative. Some of the initiatives taken by Tata Power in the clean energy development and in the community development areas are described in this paper. These are installed and enough operational experience has been gained. The leanings have been incorporated in the new designs. The paper will highlight the operational experience giving insight into the technology development and post testing phase. The operation issue in Hydrokinetic turbines, floating solar, biomass gasification and Tele Tower in existing installation will be covered in this paper.

2. TECHNOLOGY DEVLEOPMENT PHASE

The following technologies were developed and installed at Tata Power premises and in communities close to our operational area. The technologies were developed keeping in mind the DDG requirements.

3. MICRO HYDROKNETIC TURBINE

Tata Power has three hydel power plants (totaling 447 MW in Maharashtra) generating electricity by using potential energy. Further in order to utilize the kinetic energy available in tail races, Tata Power has installed a 16 KW hydro kinetic turbine in the tail race of its hydro power station at Bhira. The uniqueness of this turbine is that it can generate electricity if water streams have velocities ranging between 0.75 m/s to 4.2 m/s and at water depths exceeding 2.5 m. The plant can be seen in installed condition in Fig. 1. Tata Power in collaboration with technology provider (M/S Casmir Group) has assisted in indigenizing the turbine technology. Tata Power has designed & fabricated the power conditioning unit for making it grid tie or off grid. Tata Power is exploring the areas wherein the above technical parameters are satisfied for further installations. The Bi-directional turbine blades make it suitable tidal power generation application.

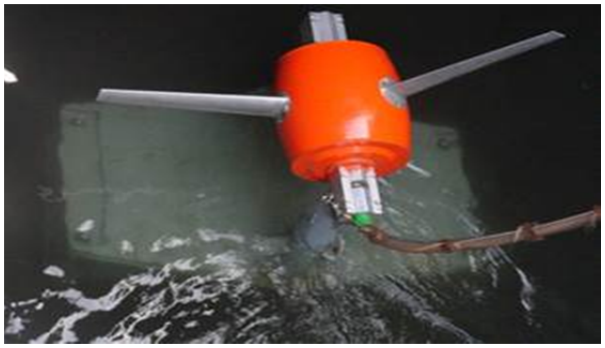

Fig. 1: Micro hydrokinetic turbine

The turbine can be installed in cascade arrangement similar to wind turbine with spacing decided by the ability to reach that velocity in that span which will be 5D or 7D based on the slope of the canal.

FIG. 2: CASCADE INSTALLATIONS

Operational learnings & Mitigation

1. The Oil hose rupture: The winding is oil immersed & is brought out to provide positive pressure and to indicate water ingress. A new reinforced hose has been used to prevent recurrence.
2. The winding failure: while trying out the new power conditioning unit with soft start, a reverse torque got applied leading to failure of the winding and mechanical damage. The reverse rotation prevention has been incorporated to prevent recurrance.

4. FLOATING SOLAR

It is well known that land is a precious commodity and solar projects require lot of land. Typical estimate is 4.2 to 4.4 acres/MW. Land availability as well as affordability are two critical blocks for any solar based power plant. To address this issue, Tata Power has designed an in house system which can support solar modules and float on water bodies. A plant of 30.6 KWp capacities has been installed in a hydro reservoir at Walvhan and is working successfully since April 2014.

Fig. 3: 30.6 KW PLANT AT WALVAN DAM

The plant is generating since installation with intermittent outages for modifications. The plant is illustrated in fig. 3.

Design aspects: Three patents have been filed for floating solar in the area of power evacuation, anchoring & modularity. Further improvement is being done post operational experience.

The FEA (Finite Element Analysis) & CFD (computational fluid dynamic) studies have been done to design the structure [3]. The following Fig. shows the pressure and wind variation on one solar pod.

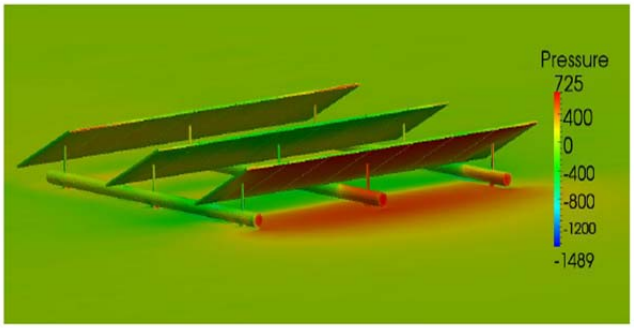

FIG. 4: WIND BACK PRESSURE CFD PROFILE

The survival wind speed is taken as 150 Kmph (41.66 m/s). This wind speed was scaled down using logarithmic wind profile for the height of the raft (approx 2m). Thus, the wind speed taken for CFD simulations is 34.044 m/s. The wind pressure is within the limit as indicated in the Fig. 4 & 5. The single raft assembly has a self weight of 928 Kg.

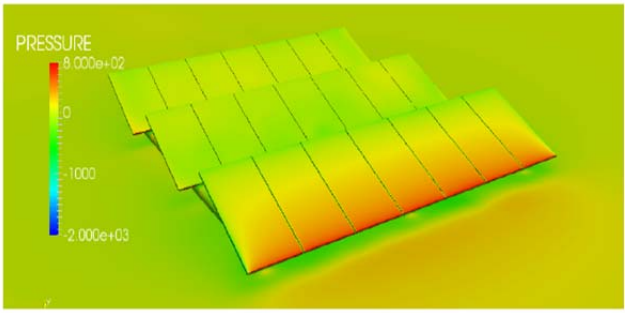

FIG. 5: WIND FRONT PRESSURE CFD PROFILE

The maximum buoyancy force that the raft can generate keeping a safe distance of 150 mm between the solar panels and the water surface is 1252 Kgf. This implies that a single raft in the current configuration can support 425 Kg additional load beyond its self weight. Hence this is sufficient buoyancy for working on raft for regular O&M (with minimum two people standing).

The floating solar system is operating since April 2015;

Operational learnings & mitigations:

1. Module cleaning: The bird's droppings on each module were observed. This is mitigated by keep modules free of pigeons Moss is also seen during rainy season. [Fig. 6]. A add on structure is being incorporated to prevent birds from using the top of the modules. The modules are cleaned with soft mop and wet clothe once in a month. The solution of antifungal treatment is being checked.
2. Maintenance platform: To facilitate ease in maintenance a fiber glass platform has been provided.
3. Solar Pod Alignment: The floating solar pod earlier it used to lose with wind force. Better anchoring is done at corners to stabilize the pods. Also an innovative self-adjusting anchoring method is being tried out.
4. Spacer bar: The interconnections of modular rafts were improved through improved spacer bars with flexible joints. This has given additional strength and stability to the rafts and entire system. [Fig. 7]

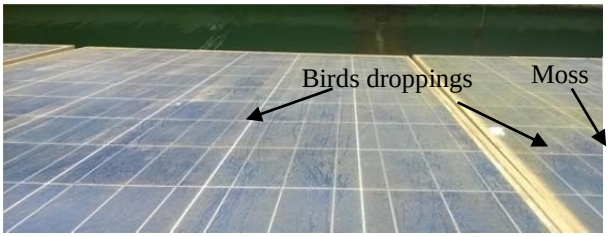

FIG. 6: BIRD DROPPINGS & MOSS

FIG. 7: FLEXIBLE INTER-CONNECTION

5. BACK UP SUPPLY FOR TELECOM TOWER TO REDUCE DIESEL CONSUMPTION

As of Feb 2011 as per Telecom Regulatory Authority of India (TRAI), India has about 3,10,000 telecom towers of which about 70% are in rural areas. Approximately 40% power requirements are met by grid electricity and 60% by diesel generators. Thus, total CO2 emissions are around 5 million ton of CO2 due to diesel consumption and around 8 million tons due to grid power per annum. In order to circumvent this problem, the Clean Tech team at Tata Power has come up with a cost effective solution which reduces CO2 emissions as well as overall energy charges of the telecom operators.

One such solution is installed with capacity of 3.75 KWp and has been catering to the electricity requirements of the double BTS site since 1/4/2015. Since the tele tower and the surrounding trees cast long shadows throughout the day, it was decided to not to use polycrystalline module. Solar Modules were procured from a CIGS manufacturer (Copper, Indium, Gallium and Selenide). The total installed capacity was 3.75 KWp. Rated power of each module is 125 Wp and five modules are connected in series to form six such strings. The feed from the array of solar modules is collected into a string combiner box and two isolated outputs are sent to the charge controller. From the charge controller, the output is connected to existing battery and power management system of the telecom tower site. The operating voltage is 48 V DC. The same can be scaled up to 3BTS load [4].

Fig. 8 gives a snapshot of the installation of the system. Replication of this solution at other tower locations will minimize utilization of diesel in diesel gen sets which are used currently for backup power requirements in telecom towers. The solution has saved approx. 13% of total consumption by providing solar energy. This uses thin film module hence ensuring generation in low DNI and even when shading occurs due to the tower & near tree as shown in fig 9.

FIG. 8: TELECOM SOLUTION

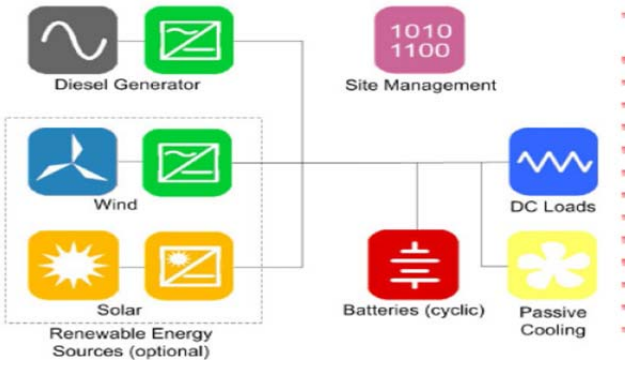

FIG. 9: THE POWER MANAGEMENT SYSTEM

Power Conditioning Unit is capable of accepting input from solar as well as grid / diesel gen set. Retrofitting is simple to the existing telecom sites. Further, better and more efficient modules were identified of 170 Wp and for a single BTS system. The wattage per square area can be increased by accommodating 27 modules totaling the capacity to 4.59 KWp

for future application. This is in-house development & is ready for deployment.

Operational learnings & mitigation:

1. Monkey menace: Since the initial CIGS modules were frameless modules which used to look like mirror, monkeys used to jump on the modules. The 16 no. of modules breakage happened. We changed over to CIGS modules with frame.
2. Soiling of modules: The bird's dropping and dust. Requires regular cleaning.
3. Loose connection in connectors: The solar strings connectors were getting loosened frequently. The make was changed for better performance.

6. BIOMASS GASIFICATION & ENERGY GENERATION THROUGH PRODUCER GAS:

As explained that there some rural communities which are still need to be electrified. Also the quality of power supply is much to be desired at many places. In some areas the solar irradiance is not adequate throughout the year necessitating a second renewable resource. It is well reported that there is ample amount of biomass (fallen twigs, branches) available in rural space, which can be utilized for gasification & consequent power generation. To harness biomass potential and uplift the life of rural community, Tata Power is working to develop a solution for power generation based on the biomass fuel. In this regards, Tata power has commissioned a 14 KW downdraft biomass based gasification system (Fig.10) which is utilized to light up the street lights in the colony. The typical producer gas composition consist of CO 19%, 18%H2, CO2 10%, CH4 3% and rest N2.The producer gas is a low calorific value fuel ranges, from 1050 to 1200 kcal/kg. The moisture content plays an important role in biomass gasification process. The moisture should not be more than 15% on weight basis. The biomass feed rate is 1.2-1.5kg/kwh. The biomass feed size is 30-40mm dia.

FIG. 10: BIOMASS GASIFICATION SOLUTION

Tata Power is also indigenizing a very efficient & compact gasifier. The new gasifier has dry cooling system unlike other gasifier which uses water for reducing the temperature of gas to be fed to engine. The system avoids use of water waste and because of high heat integration the efficiency is more than 85%. The machine has wide range for moisture acceptability upto 30% which makes it more suitable for rural application. Also system is automated which controls proper gasification process and generate cleaner fuel. The same is expected to be completed by March-2017.

Operational learnings & mitigation:

1. Biomass moisture: The biomass is sourced from residential colony and improper storage results in poor quality gas. The moisture meter was provided to check the lot randomly.
2. Water waste: the liquid waste generated is big issue in the current system and it is discarded after certain period into the garden nearby. This can be filtered and reused. However the facility is not developed for this plant. Hence working on other technologies which do not requires water at all.
3. Cleaning of filters: the filters need to clean properly after defined operation hours. The clogged filter leads to pressure drop and poor quality of gas.

7. DC GRID WITH DUAL ENERGY SOURCE (SOLAR & BIOMASS)

The shortages in peak power demand have been on an average of 12% in 2003 [2] and the rural areas are even more badly affected. India has achieved only 44% electrification for rural households [2]. In view of the problems faced by the rural communities due to lack of power and to mitigate safety risk due to possible paralleling with power illegally tapped by locals from street light, Tata Power has taken up an initiative to provide DC based micro grid power to a small community at Bhira, Maharashtra as a demonstration plant. The inhabitants of this area are predominantly “adivasi". The Project provides 48 V LEDs and fans to each household with the supply connected to common supply line in the form of a DC grid [5]. System has been designed for running on solar generation with battery providing full back up power considering 2 KW load for 41% load factor. In case solar is not available, 3 KW Biomass gasifier is installed as depicted in fig. 11. The solar based generation will be used in night time and the battery will be kept drained sufficiently to absorb the solar power in day time since the day time power consumption is almost nil. The gasification system will be run need based during monsoon.

FIG. 11: DC MICRO GRID WITH DUAL RE SOURCE AT BHIRA

DC Grid has been chosen 1) primarily for increased safety (since unreliable grid AC based power is nearby which may be used as a parallel source inadvertently by the illiterate leading to possible back feed and possible electrocution). 2) Depending on the area to be covered the losses in the grid are reduced. As part of the business model, the inhabitants will be educated on how to collect and provide sufficient biomass quantity to run the biomass system. The entire designing is done In-house.

Operational learnings &mitigation:

1. Battery discharge: There was a case of frequent battery discharge due to less irradiance & loss of alternate resources. The cut off setting point was raised in battery management system.
2. Solar module cleaning: the community is being sensitized on cleaning importance and group members were formed to assign the work.
3. Biomass fuel: The biomass collection is big issue and since they also depend on biomass for cooking purpose. Another alternate is being worked out such as palletization solution for dry leaves, to reduce this biomass collection.
4. Theft issue: The system is outside of village and there is possibility of theft, hence fencing is done. The battery & power conditioning unit is kept inside cabin which is locked by villagers.
5. Wild grass: There is wild grass growth under the panel and it grows faster. If plant grows more than module & ground clearing height it may create shadow of solar panel causing generation loss.
6. Material quality issue: Due to poor material quality, the AC alternator got magnet damaged and is being repaired. Some of specially designed 48V LED Bulbs and BLDC fan have become defective. Improvement to the driver circuit & the BLDC system being carried out.

8. CONCLUSION

The Tata Power Company has developed and demonstrated the clean technologies for various applications. These technologies are tried and tested and are now reliable. The technologies are ready now for deployment, since they are scalable and replicable and are available for commercialization. We thank the Tata Power Management for providing us the opportunity to work in the DDG area & for sharing the experiences gained in the DDG area.

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