Operation And Maintenance of Passive Infrastructure in Telecom Industry

Keyur Sudhir Shirgaonkar
Dept of Electronics & Telecommunications
Sinhgad Institute Of Technology,Lonavala , SPPU, Pune, India

Abstract- *This paper gives an idea about role of the passive infrastructure in telecom industry at various sites in India. It not only gives a detailed description about the various equipment used like diesel generator, electric grid, battery banks, SMPS, PIU/AMF etc required for running a telecom site but also provides opportunities for development by replacing the non-renewable energy sources with renewable energy sources by providing greener and newer solutions keeping environment into consideration. It also explains the role of technical support structure for the network operation, maintenance and upgradation of various sites around the globe by keeping cost and optimal utilization of greener resources in mind in order to produce most efficient result which at the same time are environment friendly and are made available at reduced cost.*

Keywords- Passive Infrastructure, Technical Support Structure, Renewable Energy, Operation and Maintenance.

I. INTRODUCTION

Telecommunication services are known as one of the key driving forces for the socio-economic development of a nation. The significant growth of the Indian telecom industry over the last few years can be characterized by the operational prudence and exploding data growth along with a decline in tariffs due to the fierce competition [4]. Moreover, telecom operators are laying emphasis on operational prudence more than ever. Tower organizations are playing a major role by partnering with telecom operators and helping them optimize operations and therefore reduce costs. With this shift, tower organizations are adopting innovative models, advance fuel management technologies, data analytics and also high efficiency equipment and green energy. They have also started focusing on new areas and interacting with great number of ecosystems. This brings us to the topic emerging focusing area in tower industry which is passive infrastructure as well as energy and resource management. Due to rising rates of properties, telecom infrastructure sharing among the telecom organizations has become the need of the hour. This will also help to lower the increasing investment by partnering with the competitors which in turn will increase the profits of the independent organization. The method for sharing of telecom infrastructure is as follows:-

Passive infrastructure sharing: It is sharing non-electronic infrastructure at cell site i.e the elements which enable the active infrastructure to operate at respective sites [6]. Passive infrastructure sharing involves multiple operators sharing the same passive infrastructure as a means to reduce the costs associated with real estate, access rights and preparing sites[3].Passive Infrastructure sharing is becoming popular in telecom industry not only in India but also worldwide.

Along with passive infrastructure sharing, there is now public and regulatory pressure to reduce telecom towers energy consumption and pollution, especially from diesel generators.

With a holistic approach and collaboration with O&M (Operation and Maintenance) and service providers, the tower industry can move to a greener value chain which consist of low power consuming green active equipment, high energy efficient green passive configuration and equipment, efficient sharing and renewable sources of energy.

II. RELATED WORK

The related work for operation and maintenance of passive infrastructure at sites includes daily checking of diesel generator after start and servicing after regular intervals of time, troubleshooting of automatic voltage regulator if a problem occurs, keeping an eye on unreliable electrical grid supply, verifying the controls of power interface unit, tracking the smps rack for predetermined stable output supply as per site requirement, adjusting the on and off time of dc to dc converters for regulated output voltage even though current demand changes and checking the battery banks as well as keeping a regular watch on alarm generation and analyzing the instruction and taking measures accordingly for reliable and efficient running of various equipments which in turn helps to keep the site running 24x7.

III. SYSTEM DESIGN AND DESCRIPTION

The diagram below shows how different equipments are interconnected at a telecommunication site. In brief, at any given time power supply is given to the equipment from either the electric grid or the diesel generator. Which of the two should provide power at a given instant of time is chosen by the AMF/PIU panel. The supply, for the purpose of being rectified is supplied to the SMPS rack which gives a predetermined stable output of either -48V or -24V as per the site requirement. The SMPS provides supply to the BTS which is then connected to the transmission tower. The SMPS also supplies power for recharging battery banks and for running the auxiliary equipment like air-conditioners.

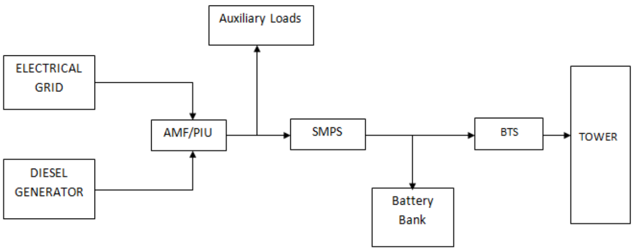

Fig.1) Site Diagram & Layout

The detailed description on each block in passive infrastructure is as follows:-

1) Diesel Generator: A diesel generator is the combination of a diesel engine with an electric generator to generate electrical energy. This is a specific case of engine-generator. A diesel compression-ignition engine often is designed to run on fuel oil, but some types are adapted for other liquid fuels or natural gas. Diesel generating sets are used in places without connection to a power grid, or as emergency power-supply if the grid fails, as well as for more complex applications such as peak-lopping, grid support and export to the power grid. Diesel engine are made to last. The engines run at a low RPM level, they are water-cooled and, as a result, they run tens of thousands of hours before requiring a significant amount of maintenance or repair work. When some companies inevitably go under, low-hour diesel generators become available at significantly reduced prices. By buying low-hour diesel generators, most purchases are able to gain all of the benefits of having a new genset, but at a lower price. The figure below shows an example of diesel generator:-

Fig.2) Example of Diesel Generator

2) Auto Mains Failure(AMF)/Power Interface Unit(PIU): Automatic mains failure (AMF) panels also referred to as automatic transfer switch panels make the power switch to emergency standby generators in the event of a significant loss of mains power or total blackout. Without AMF panels, generators need to be operated manually and that can mean lost data, potential damage to electrical equipment and huge amounts of disruption. AMF board and ATS panels monitor the incoming AC mains supply, activate the standby generator when mains power fails and make an automatic electrical transfer of the building's load from the mains to the generating set. When the mains supply returns, the ATS panel controls a return to the mains supply and shuts down the generator after a suitable cooling run. High-tech electronic control systems enable a wide range of activities, including full mains synchronization where a no-break changeover is required. PIU converts 3 phase ac power supply in 230 volt ac with stabilized and no surge and interference effect. The figure below shows an example of power interface unit:-

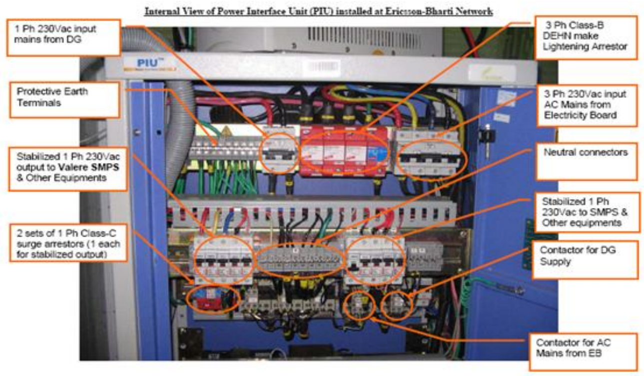

Fig.3) Example of Power Interface Unit (PIU)

3) Switch Mode Power Supply (SMPS): A switched-mode power supply (SMPS) is an electronic circuit that converts power using switching devices that are turned on and off at high frequencies, and storage components such as inductors or capacitors to supply power when the switching device is in its non-conduction state. The main advantage of the switching power supply is greater efficiency because the switching transistor dissipates little power when acting as a switch. Other advantages include smaller size and lighter weight from the elimination of heavy line-frequency transformers, and lower heat generation due to higher efficiency. Switching regulators are used as replacements for linear regulators when higher efficiency, smaller size or lighter weights are required. They are, however, more complicated; their switching currents can cause electrical noise problems if not carefully suppressed, and simple designs may have a poor power factor. SMPS used in telecom industry consist of no of rectifier modules which perform the operation of AC to DC Conversion as per the requirement of BTS and Battery Banks and they also help in giving a constant voltage with the help of voltage regulator. Generally the SMPS operates in three different modes depending on the case:-

1) Float Mode: 54.5V (Normal operation)
2) Boost/Charge Mode: 55.5V (If Battery gone under discharge less than 10% of capacity, after restoring the AC power the SMPS will automatically S/W on into Charge mode)
3) 3) Equalize Mode: 56.5V (If Battery gone under discharge more than 10% of capacity, after restoring the AC power the SMPS will automatically S/W on into Charge mode)

The figure below shows an example of Switch Mode Power Supply Rack (SMPS):-

Fig.4) Example of Switch Mode Power Supply Rack [7]

4) Battery Banks:-Batteries often used in battery rooms are the flooded lead-acid battery, the valve regulated lead-acid battery or the nickel–cadmium battery. Batteries are installed in groups. Several batteries are wired together in a series circuit forming a group providing DC electric power at 12, 24, 48 or 60 volts. Usually there are two or more groups of series-connected batteries. These groups of batteries are connected in a parallel circuit. This arrangement allows an individual group of batteries to be taken offline for service or replacement without compromising the availability of uninterruptible power. A valve-regulated lead-acid battery (VRLA) is a battery type that is popular in telecommunications network environments as a reliable backup power source. The figure below shows a perfect example of battery bank used at sites.

Fig.5) Example of Battery Bank

5) Tower (GBT/RTT): Telecom towers may be a ground based tower (GBT) or a roof top tower (RTT). Ground based towers are erected on the ground with a height of 40 meters to 80 meters. These ground based towers are mostly installed in rural and semi-urban areas because of the easy availability of land. Ground Based Towers involve a capital expenditure of around Rs 2.5 million depending on the height of the tower. A GBT can accommodate 5 to 6 tenants in its tower. Roof-Top Towers on the other hand are placed on the terrace of high-rise buildings particularly in urban areas. In cities like Mumbai and Delhi where the high rise buildings are available, instead of towers poles are erected for installing antennas which are called as roof top poles(RTP).

IV. IMPLEMENTATION

The system can be implemented for workplace environments where high electric or magnetic field strengths are likely to occur. In case of a typical cell tower, the power demand is determined by the number of base transceiver stations (BTS). The power demand ranges from 1kW to 8.5 kW where more than 85% of these configurations have a demand less than 3.5 kW. To ensure power availability of more than 99.90%, tower owners backup the electrical grid with combination of batteries and diesel generator. At most sites, the tower owner installs diesel generators of 10 kVA to 15 kVA capacity and supplements it with battery banks of 300 Ahr to 900 Ahr capacities. The diesel generator and battery configuration are decided based on power outage pattern, equipments at site, geographical locations and optimal CAPEX and OPEX. When the power from the electrical grid is available, Power Interface Unit (PIU) selects the best phase of 3 phase electrical grid and provides power to the rectifier or switch mode power supply (SMPS).The SMPS converts the

220 VAC to -48VDC or -24VDC as per the requirement providing power to the telecom tower equipment and additionally, to charge the batteries. When power from grid is interrupted, the PIU sends a signal to the diesel generator to turn on and the diesel generator comes on line in a few minutes. It supports the entire power requirement at the site. During the transition of supply from electricity grid to diesel generator, the batteries provide the power required by the telecommunication equipment at the tower and ensures uninterrupted operation of the telecom site.

V. RESULTS

The subscriber base usage of 3G user has grown at a CAGR of 144% from 2009 to 2014 and is expected to grow further at more substantial rate. Along with overall increase in network area, falling data prices and customer moving to higher connection speed there is need for adopting faster and reliable system which are ecofriendly [4]. The figure below is analysis in millions of subscriber base by technology:-

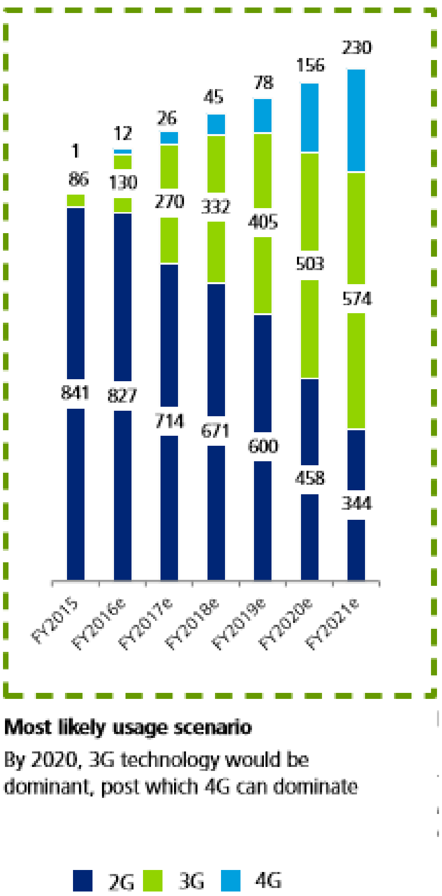

Fig.6) Estimated Subscriber Base (in million)[4]

Along with increase in user base and people shifting to use of more advancement in technology we have to adopt measures from burning thousands of litres of diesel and preventing carbon emission into the atmosphere. This can be done by using power management solutions based on renewable resource. Focus should be shifted therefore should be shifted by telecom companies to reduce the opex cost rather than capex budget by using green base station which would be reducing the cost in long run as well as no harm would be done to the environment. The figure below shows how clean energy would be extensively used in future due to depletion of fossil fuels:-

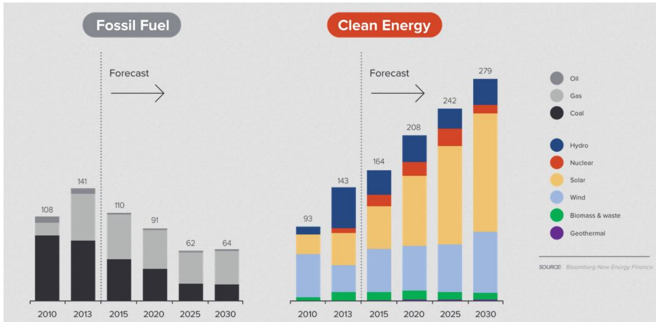

Fig.7) Forecast Of Global Power Generation[7]

The figure below shows call setup success rate in Mumbai of various telecom organizations since there has been increase in use of renewable resources:

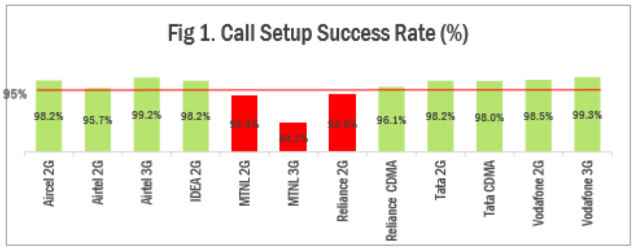

Fig.8) Call Setup Success Rate[1]

The examples of the readings of actual emf measurements after usage of clean energy will be seen as follows:-

	Item	Units	Vodafone 2G			Vodafone 3G			Airtel 2G			Airtel 3G		
			Sec-1	Sec-2	Sec-3	Sec-1	Sec-2	Sec-3	Sec-1	Sec-2	Sec-3	Sec-1	Sec-2	Sec-3
SITE DATA	Site ID		3302			3302			1194			1194		
	Name		Arjun Niwas			Arjun Niwas			ARJUNNW			ARJUNNW		
	Date of Commissioning		30-Aug-08			27-Aug-14			24-Jul-02			28-Dec-10		
	Address		Bhatt Lane, Poisar, Kandivali West, Mumbai-400067			Bhatt Lane, Poisar, Kandivali West, Mumbai-400067			Bhatt Lane, Poisar, Kandivali (West).			Bhatt Lane, Poisar, Kandivali (West).		
	Lat / Long		19.21441/72.84992			19.21441/72.84992			19.21441/72.84992			19.21441/72.84992		
	RTT / GBT		RTP	RTP	RTP	RTP	RTP	RTP	RTP	RTP	RTP	RTP	RTP	RTP
	Building Height AGL	(m)	25			25			25			25		
	Antenna Height AGL	(m)	29	29	29	29	29	29	33	33	33	33	33	33
	Make and Model of Antenna		Andrew QBXLH 6565 C-VTM	Andrew QBXLH 6565 C-VTM	Andrew QBXLH 6565 C-VTM	Andrew QBXLH 6565 C-VTM	Andrew QBXLH 6565 C-VTM	Andrew QBXLH 6565 C-VTM	ANDREW-TBXLHA-6565C-VTM	ANDREW-TBXLHA-6565C-VTM	ANDREW-TBXLHA-6565C-VTM	ANDREW-HWXXX-6516DS-VTM	ANDREW-HWXXX-6516DS-VTM	ANDREW-HWXXX-6516DS-VTM
	System Type (GSM/CDMA/UMTS)		GSM			UMTS			GSM			UMTS		
	Base Channel Frequency	(MHz)	957.8	936.2	937.2	* 942.6/2161.5	* 942.6/2161.5	* 942.6/2161.5	1871.6	1871	1872	2166.6 / 957.4	2166.6 / 957.4	2166.6 / 957.4
	Carriers / Sector (Worst)		6	6	6	** 2	** 2	** 2	6	5	5	2	2	2
	Tx Power	(dBm)	43	43	43	43	43	43	43	43	43	43	43	43

Fig.9) Actual Site Report

VI. LIMITATIONS

The passive infrastructure currently existing in the telecom industry sites all over the world has certain limitations. Non-electrified cell sites rely on diesel generator sets extensively for their power requirement, therefore consuming significant volumes of diesel. The volume consumed varies depending on tenancy at the site, which can sometimes take the DG running hours upto 20 hours per day and also cause a lot of CO_2 emission which is very harmful to the environment. To overcome these challenges, we need to use renewable energy solutions like solar photovoltaic, wind power, fuel catalyst and fuel cells as alternative solutions. Solar photovoltaic can generate power during sunshine hours but it is not totally feasible since it requires running battery bank at non sunny hours and is not standalone solution. In case of wind power, quality wind speed differs from area to area therefore windy areas can implement such technology but it is unreliable for less windy sites. Fuel cells convert the chemical energy of hydrogen into electricity through a chemical reaction with oxygen or another oxidizing agent, emitting zero emissions at the source. This technology had been predicted and is currently replacing diesel generator, reducing diesel consumption as well as CO_2 emission. Fuel cells have higher efficiency when compared to other renewable energy solutions. Owing to significantly better efficiency versus load characteristics, fuel cell systems can also be used in reduction of the energy requirement of the telecom sites. Fuel catalyst technology once fully functional has been expected to reduce diesel consumption by 6%-9% per year [5].

VII. CONCLUSION

There are many ways to manage the power deficit, the most popular being the use of diesel generators. The use of diesel generators on a large scale is causing the telecom organizations to incur huge costs along with harm to the environment. One of the way that they can manage the power supply and reduce the cost is by maintaining sufficient battery backup. The batteries that are used also play a role in determining the maintenance cost of the site. The tubular gel batteries are efficient in storing charge and they have a long life i.e. more number of charging cycles. The green way to compensate for the power deficit is to make use of solar, wind energy, fuel cells and fuel catalyst as discussed earlier. It can start with using a customized solution specific to a site (which takes into account the amount of time the electric power is available, the battery backup, the atmospheric temperature swing from day to night, the weather profile for amount of sunlight and wind the site sees etc.) which combines the use of green as well as non-renewable resources for optimal functioning of the site and minimizing the cost and the impact of site operation on the environment. After all in the long run, the equipment although costly, is going to give back considerable returns if maintained and used with proper planning and care.

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