



International Journal of Engineering, Business and Enterprise Applications (IJEBEA)

www.iasir.net

DIFFERENT POWER SUPPLY PLANNING OPTIONS AVAILABLE FOR A BTS SITE

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Abstract: Telecommunication network is growing day by day, more subscribers are being added with all around 6 billion all across the world. With so much subscribers comes countless number of BTS sites which require huge amount of power or the electrical supply to perform the functionality and services. But how should an operator decide the power sources? What are the various power options? Is it the part of the network planning? Site planning? Or there is another team dealing with the power planning at a BTS site or for the entire cluster. In order to answer the question of whether power is a consideration in network planning, it is useful to examine what are the various power options that an operator can look for while planning a site. There are different power sources available to use, which one should an operator opt for? This paper will present literature on different power sources and their pros and cons.

Index Term: BTS, RBS, CAPEX, OPEX, DG.

I. INTRODUCTION

In telecommunication applications, a remarkable increase in the number of installations has been seen over a period of last decade in which the number of subscribers has increased from 2 billion to over 6 billion according to the ITU. The advancement in telecommunication sector of today is unrecognizable from the Bakelite handsets and manned exchanges few decades ago to the technologies like the web, broadband, 3G, LTE, cloud computing, VoD etc[1]. But sometimes these systems are located in highly remote areas where the supply of power requirements been an important concern in order to guarantee the remarkable QoS anywhere and anytime. The typical mobile network composed by three different sections:

1. The Mobile Switching Center (MSC), which is working with switching and acting interface to the fixed network and other networks as well[2].
2. Radio Base Station (RBS) or the Base Transceiver System (BTS), which works between the network and the mobile terminal and acting to provide the frequency interface between user and the network.
3. Mobile terminals or the mobile stations, which is the subscriber's part, i.e. the mobile handsets and the SIM.

It has been determined that out of the total energy consumed by the system, 90% of this was used in system that is operating the operations. For this the key element is the BTS or RBS site that have high power consumption because they are being deployed over a large number. While the number of core elements like MSC is relatively very much low which results in comparatively low power consumption and then the Mobile Stations which are mobile in nature and have even lower power consumption. Base station site planning and network design criteria varies operator to operator but power is often not considered until a particular design state where there are problems regarding the availability of power supply[3]. A typical BTS site requires -48V power supply. Power supply is taken with negative reference so that noise should not affect the system as the noise should not affect the system as the noise always attacks on positive polarity. The input power from the supply is fed into the PDU which is the power distribution unit and from there it goes to the rectifier which converts AC supply into DC supply. Typical rectifier and PDU unit are shown in figure 1 and figure 2.



Figure1: Rectifier equipment at BTS site



Figure 2: PDU unit

A. Traditional Network Planning Process

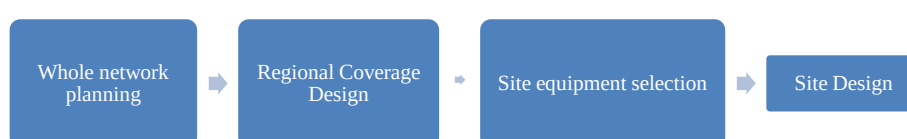


Figure 3: Network Planning

Should the power planning been taken as the part of network planning process, sites must have been located at the places which are more close to the electricity grid, or the places where it is easy to transport the fuel etc. and also green power must have been deployed by now. Site location and selection of BTS equipments put a significant impact power CAPEX which states that a power expert should be involved in the network planning process [3].

B. Site Location Considerations

When site locations are defined during the network planning process there are specific considerations particular to power solutions: The site location must be such where electrical grid is there in the vicinity. Site location should be such where diesel can be transported easily and can be buy from the nearby area only so that transportation cost should be minimized. Ease of access is required to allow installation and maintenance.

II TECHNOLOGY AND POWER CONSUMPTION

With the advancement of technology and BTS design, less power consuming systems are developed. Replacing existing equipment, but retaining a diesel generator as the power solution, offers a potential business case for more established operators. By replacing old, energy inefficient equipment, the load requirements of the base station site are reduced and a more appropriately sized generator or other power sources can be installed.

A. Site Power Consumption

There are numerous equipments that consumes power at a BTS site and the total power consumption can be distributed as shown in the figure 2. Using the latest equipment the following loads can be reduced. Base station site power consumption is primarily from the base station equipment, active cooling, backhaul, lighting& monitoring. There are numerous approaches to reducing power consumption. Removal of active cooling and the use of remote radio heads allow significant reduction in base station site power consumption.

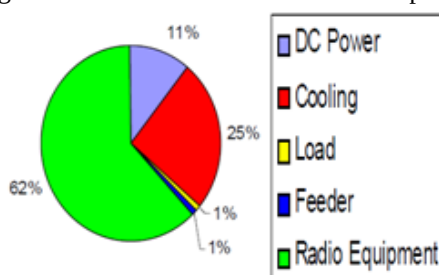


Figure 4: Power Consumption at BS

B. Different Power Options

There are large numbers of solutions to the problem of power supply procurements. Selection of the efficient solution will depend on the circumstances.

1. **Mains power or the grid supply:** This may already be available, or can be provided via grid extension. New grid connections can be very costly and can also take months or even years to be installed. However where mains is readily available it will normally be the solution of choice. In some cases where there are frequent interruptions to the supply a battery back-up unit can be a wise precaution. In difficult locations, it is not uncommon to have to pay up to \$100k for a mains connection.
2. **Generators:** If grid connection is delayed or electricity supply expected to be very intermittent, generators are often installed. These will need to be refueled, and due to portability and value of both the generators and associated fuel, they may become a target for theft. Bio fuel generators are more environmentally friendly, though may not overcome issues of re-fuelling cost and theft.
3. **Battery Bank:** The battery bank is made up of battery cells ranging from 2V-6V, string up in series to achieve the desired -48V. Use of 2V cells provides better battery reliability as failure of one cell only reduces the system voltage to 46V while only 42V is left if a 6V cells fails. Some equipment may be affected by such a fall in system voltage. The advantage of 6V battery cells is the lower cell count in a battery bank. There should be two number of battery bank to allow for any one of them to takeout for maintenance purposes[1].

III. GRID SUPPLY

There are three types sites depending upon the location of the grid

1. **OFF-Grid:** When the site is not getting any power supply from the grid or the site is at remote location where power grid supply cannot reach.
2. **ON Grid:** When the site is taking the power supply from the grid in order to perform the operations.
3. **Unreliable grid:** very common in developing countries where power supply to BS is coming from the GRID but an operator cannot rely only on the GRID power, a power backup should be ready all the time.

A. Advantages and Disadvantages

If grid power is available on economical terms it should be used as the primary source of the power. Grid supply has number of advantages over diesel supply.

- Lower OPEX than diesel generators
- Minimum maintenance required as the primary source.
- Ease of scalability of site to higher power consumption
- Lower emissions than using diesel generators.

But for developing nations, availability of grid supply can be an issue. Distance between the grid and the site and local terrain affect the economics of the grid. Availability of grid connections may not be instantaneous it may take 6 to 12 months or more.



Figure 5: A 3-Phase supply from GRID

B. Distance and Terrain Limitations

The CAPEX for grid varies country to country and depends mainly between the distance between the GRID and the BTS site. And also on the terrain on which the connection is to be made, for example, a BTS located at hilly region, GRID supply may not be available.

C. Unreliable Grid Electricity

In many developing countries, the electricity grid is highly unreliable which calls for a power backup like diesel generators or the batteries. According to various operators, the availability of grid power in india ranges from 10 to 12 hours every day only.

D. Impact on Network Performance

If a BTS site is provided only grid supply with no power backup then on the failure of GRID supply, site will not functions. In many cases when the traffic through a site is shared, the entire ring gets down and causes heavy outage to the network operator.

The grid coverage in the developing countries is increasing with the increase in the economic development. But with the increasing demand, the trouble of load shedding coming more and more into play where power is cutout in the particular areas of the country to prevent the burnouts. Some of the operators said that telecom sector is not a priority sector for the electricity grid which makes it tough for the operators to draw the reliable power[4].

IV. BATTERY SUPPLY

Batteries are an important source in off grid and unreliable grid power solutions. The lead-acid car batteries are of no use for base station site-backup because they provide large bursts of energy. Rather, BTS site systems require a battery which can run along with multiple charges and discharges over extended periods.



Figure 6: Battery Bank of a BTS site

A. Types of Battery Technology

There are different types of batteries available with individual advantages. Open wet cell batteries are good when the sites are easily accessible[5]. Flow batteries are based on new technology and possess a long life. Lead acid batteries are rated at 25°C. After this, battery lifetime decreases significantly. If a lead acid battery is maintained at 35°C, it will have 50% of the rated life. Flow batteries are designed to work up to 40°C. If the temperature goes beyond, the battery will stop work temporary. Therefore it is very important to carefully control the environment of all battery types.

B. Battery and outage

1. For grid outages of less than eight hours a day, batteries alone may be a suitable solution.
2. Repeated cycling of batteries can shorten battery lifetime.

In traditional way, outages are compensated by diesel generators or batteries. Batteries are preferred over diesel generators because they do not need fuel to be kept on site, no emissions or noise, and easy maintenance. Batteries have high CAPEX but low OPEX as compare to DG set as there is no diesel cost.

C. Impact of Battery Cycling

For a lead acid battery, lifetime is determined by the number of cycles through which the battery is charged and discharged. Longer and deeper cycles means heavy reduction in the lifetime. Incase when the grid is unreliable, the optimum battery lifetime and size determination in difficult to calculate. Furthermore, lead-acid batteries require consistent charging regimes so that they can be fully charged.

Table 1 : Different types of batteries and their comparison

	Maint-enance	Life-time	Controller	Cost
Lead-Acid Wet-Cell	High	Long life upto 2000 cycles	Needs good charge controller	Low Cost
Lead-Acid (Gel)	NO	Shorter life than wetcells	Less susceptible to charging problems	Mid cost
Flow Batteries	Low	Lifetime guaranteed for 10 years	Integrated controllers manage charge/discharge	High cost

V. DG POWER SUPPLY

Diesel consumption varies greatly based on the utility of diesel generators as a power source. There are sites that only rely on DG sets because of no grid power availability. An approximate fuel consumption for such sites is 1500 liters/ month for a DG less than 15 kVa. There are certain factors that affects the use of DG as a power source in OFF grid areas and Unreliable grid areas[6][7][8].



Figure7: DG set for a BTS site

A. Cost of distribution

Either operator can manage the fuel distribution internally or through an outsource distributor and vendor. Usually operators prefer outsourcing distributor. Distribution costs are material which results in substantial premium to regional pump prices. In extreme case, the cost of distribution may exceed then the cost of the fuel.

B. Security

The vehicles that distribute diesel are attractive targets for theft. Sometimes theft occurs internally within the distributor or externally. Operators estimate that on average, 10% of fuel costs are a result of theft, which in certain cases rise to 40% to 50%.

C. Diesel Theft

Operators are occasionally facing the troubles of theft of fuel in their network fuel supply chains. This can occur at the following points

1. by external distributors (tampering of fuel or incorrect book-keeping)
2. Loss during transit
3. From site after distribution

D. DT Theft

DG sets used are heavy and are deployed on heavy metal or concrete housing and heavy lift equipments are required for the deployment but even then there are always on risk of theft of DG.

E. Maintenance Requirements

DG sets require regular engine servicing and routine oil change. Generator oil samples are also collected on timely basis to assess the health of the DG sets and predicts if the replacement is required in coming time or not. Servicing of DG sets are required at 250 hr runtime intervals. When the sites are running on DG with no power from electric grid, this requires physical site access in every 10 to 12 days.

Maintenance costs for DG sets include the cost of replacement of parts which can be treated as the foxed cost and the cost of a mechanic to carry out the replacement which depends on many factors such as distance travelled to sites, labour rate, and the skill of the mechanic.

F. Scheduled Maintenance

Scheduled maintenance depends of DG sets depends on how long the generator has been in operation. In the initial months, fuel and air filters need to be replace and oil levels check is required. In mid life, the DG set will require an oil change and injector pumps and injection nozzles may need cleaning or replacing. At the end of DG set's life, maintenance activities increases with major parts demanding for replacement. Generators operating 24 hours/day will require replacement or complete overhaul approximately every 18 months.

G. Fuel and Oil Quality

The quality of the fuel and oil used owns a significant effect on the life of the DG. When low quality fuel is used, filters, pumps etc needs more frequent replacement. Its good if the fuel is treated with additives which improves its quality, but feasible only when fuel is treated and stored in bulk quantity.

VI. SITE SHARING

Site sharing improves the economic viabilities of the network infrastructure investment for low volume rural sites. Site sharing is defined as the sharing of physical infrastructure like space, tower, infra resources, security etc by multiple operators. Individual operators retain their core BTS equipment ownership and network propriety. Shared infrastructure can be attractive in both urban and rural regions. In urban areas where there are multiple operators working and no good free space is available to install the infrastructure, site sharing is a good option. Also in rural areas where subscribers and the revenue is less so operators coexist together on s single infrastructure so that installation cost should not cost too much [1].

Certain governments have put some regulatory pressure on the operators to expand their coverage into rural regions with low call volume. Indian government has also initiated one such scenario known as Universal

Service Obligation which brings mobile coverage to every village in which most of the villages are completely off grid. In such cases site sharing is must have option for the operators because even after the subsidy that government is funding, such sites have less revenue and high CAPEX and OPEX.



Figure 8: Tower showing Sharing

A. Advantages of Site Sharing

1. Mobile towers are a shared cost supporting multiple BTS units and this reduces the CAPEX and OPEX.
2. Centralized site security.
3. Power sourcing and backup can be consolidated to provide of scale and improved stability.
4. Operators can be added incrementally to shared sites, which support 2-5 operators.

B. Trends with Site Sharing

Out of these advantages there is one big disadvantage of site sharing, for a particular site, the power requirement increases. Site sharing provides numerous advantages over installing individual sites. Outsourcing the infrastructure allows operators to emphasize core business operations. Due to load of multiple operators, business models and assumptions for shared sites are different from the one planned for individual sites.

VII. POWER DRAWN BY BTS

Table 2: Power Drawn by different Base Stations

Type of Base Station	Power Consumption(may vary with local conditions)
GSM Base Station 2/2/2	600-1800W
GSM Base Station 4/4/4	900 – 2300W
UMTS Node B Macro/Fiber 2/2/2	750 – 1000W
Macro/Fiber — 4/4/4	1300 – 1700W

VIII. CONCLUSION

This paper has presented various power supply methods an operator can use to provide electrical power. There has been various issues in order to select the right source of power for a site and all those are clearly mentioned here. Telecom sites run with different power options like GRID power, Battery backups and DG power supply and it requires huge planning to decide which site should be provided by which power source. All the images of the equipments like rectifier, battery bank etc are captured while physically auditing the sites. In the developing nations like India, it calls for more and more research to use renewable power resources to meet the satisfactory demand so that the pollution via these sources can also be controlled. Also all the pros and cons of the different power sources are studied and mentioned which are always useful in deciding right power source for every individual site.

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