

# A REVIEW: MAIN ASPECTS OF POWER CONSUMPTION IN WIRELESS NETWORKS

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## ABSTRACT

The power consumption of wireless access networks is becoming an important issue in the green cellular-technology. The concept of green 4G LTE system depends on enhanced design strategy of efficient LTE energy system in order to reduce greenhouse emission as well as operators energy bill. In this paper we deal with study and analysis of the investigating power consumption in wireless network and investigating the possible way to reduce the power consumption at Base Station. We also characterized the techniques of the power consumption in wireless network and to explain the latest work on this way. This paper is also showing that the effects of the techniques on power consumptions which are used by many authors.

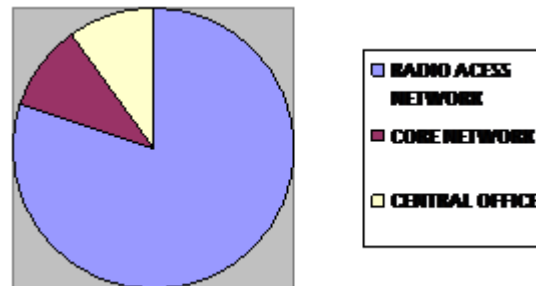
**Keywords:** Base station, Fuel cell, Pico hydro, Sleep modes, Solar and Wind power.

## I. INTRODUCTION

As we all know that the energy consumption in ICT industry has become a very serious issue from either economical or environmental perspective. Recent research shows that nowadays the Information and Communication Technologies (ICT) sector is responsible for 2-4% of the worldwide carbon emissions which will even double in the next 10 to 15 years, if no precautions are made. A significant amount of these emissions, about one sixth, is caused by the telecommunication networks. Furthermore, the Wireless World Research Forum (WWRF) expects that by 2017 7 billion users are served by 7 trillion wireless devices.

In the struggle for reducing the environmental impact of information and communication sector emphasis Telecommunication and wireless network, power consumption of the network has become more attention topics. Many research paper and previous studies shows that mobile communication network are responsible of small sharing of total globally energy consumption, reducing this power consumption has become an essential key from perspective of environment impacts and operator cost views. Approximately 90 percent energy consume due to the core network, and radio access network (Mobile Station and Base Station) in wireless network and whereas the BTS is the main energy consumption component which consume maximum energy of that. Within base station, a huge amount of energy is wasted in the power amplifier and through the antenna feeder cable. The wireless network can be viewed into three major subsection-core networks that is working as switching system, interface to fixed network and billings system. 2nd base station (BTS) which is established the radio frequency interface between the network and mobile station. Other, mobile station, which is used by the subscriber making a phone and data call. The core network and Radio Access network – (base station, MS) is energy greedy. It is estimated that over 90% of the energy Consumption in wireless network due to those two elements. Today, there are quite a number of technologies that helps to reduce base station power consumption,

such as the software solution which save power through turning off selected carriers on low traffic periods, the green energy solution which offers solar wind and other renewable energy for base station's power supply according to local natural conditions, and the energy-saving air conditioning technology which combined with the local climate and environment characteristics, reduce the energy consumption of air conditioning equipment etc [2][3][4].



**Fig:-1.1 Consumption of Energy In Wireless Networks**

## II. RELATED WORKS ON THE ENERGY SAVINGS

There are several works which have done to measure the energy consumption and CO<sub>2</sub> emission in the different part of telecommunication network. It estimated that more than 90% power consumption in the wireless network by the operator parts. The operator parts consist of the two components –one mobile switching centre including BSC & radio interferences and billing system and others mobile base stations (BTS).The base station consume maximum power of it. Some method in order to reduce the energy consumption as improving transmitter efficiency, system level features to use air cooling, to use alternative energy source (wind, solar etc.) and during the low traffic load (night period) [2] [3].CO<sub>2</sub>.The author proposed three step in [2] in order to reduce the power consumption and CO<sub>2</sub> emission in wireless network –to minimize BTS energy consumption, to minimize the numbers of BTS, using renewable energy source [2].

This paper [10] also showed that energy consumption in wireless network during the various traffic loads. They also proposed that to reduce the numbers of some active devices during low traffic such as night time and weekend day, then it is more possible to save energy [10].

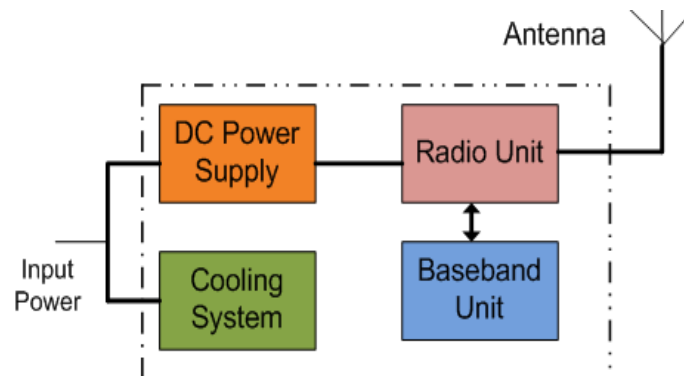
The 2% of the input dc voltage is using at the transmitter as RF power because due to inefficiencies of the RF power amplifier and rest of power is to use for the radio equipment and signal operation and also a large amount radiated as heat. The [5] paper, we propose a cooperative sleep-mode strategy for heterogeneous mobile networks where several small cells supply the overlapping coverage, and provide a mathematical model for analyzing the performance of the strategy.

## III. POWER CONSUMPTION DUE TO THE BASE STATION EQUIPMENT

Base station is the main power consumption element in the cellular network. It consume more than 90 percent power overall network. The power consumption of BTS depends on the type of base station like macro base station, micro base station, Pico base station and depends upon base station sectoring. It can be one; two and three sector cell pattern .Normally power consumption of macro base station is higher than micro and Pico base station.

Base station consists of few elements such as DC power supply, Cooling System, Radio unit and base band unit.

The following figure the Base Station Block diagram.



**Fig 1.2: Base Station Block Diagram**

### 3.1 DC Power Supply

The basic function of power supply is to produce a power for whole equipment of Base station transceivers. It takes AC supply as an input and produce DC voltage as power. To set DC power supply in order to provide the suitable DC supply to Radio equipment and Base band unit in the Base station cabinet. The size and capacity of the DC rectifier is depending on the several of the Base station cabinet size like small system, medium system and large system. Approximately 11 percent of powers are consumed due to DC power supply at the Base station cabinet [8]. Example specification of the DC power supply of base station cabinet is given in the following electrical Specification of DC power supply.

**For small system:**

**For medium system:**

INPUT	OUTPUT
Voltage range 220V ac (150V~300V)	Voltage :-48Vdc
Current 18 A	Current:40 A
Frequency:50Hz(47~63Hz)	Maximumpower:2260 W
Efficiency 87%	

INPUT	OUTPUT
Voltage range:150V~280V	Maximum output power 4250 W
Current 33A (Max.)	Voltage:-48Vdc
Frequency 50 Hz (47~63Hz)	Current 75 A

Table 1: Specification for DC power supply for small system

Table 2: specification for DC power supply for medium system

This DC power system can be used for GSM, CDMA base transceiver, module station, rural station, small capacity switching office in local network

The large DC power system is used when the system cabinet is to need greater than 4000W power [10]. It has a large capacity. This power system can be used for mobile switching centre, Base station controllers, GSM base station, CDMA base **station Cabinet, terminal station, transmission** equipment and data communication equipment. It Also has AC input capacity such like 415Vac (AC Voltage), 50A.S

### 3.2 Cooling System

Nowadays wireless sector is demanding how to decrease the energy within separate temperature zone in an electronics enclosure extended life span and want to confirm that every component in an electronic shelter or

cabinet should be worked in its high performance. Power consumption of base station is much larger than any other public institute (buildings) because of a large amount of heat is generated from telecom components and environmental requirement for their suitable operation. Approximate 25 percent energy consumed which is due to air condition ring or cooling system out of the whole energy consumption of base station [19]. A large amount of BTS are installed over the world within telecommunication network. Cooling system or air-conditions system adds more energy consumption over the wireless network. That is why energy savings gets more attentions.

Radio base station used in mobile telecommunication systems is responsible for producing an amount heat and which needs to be removed. A typical Base station cabinet can produce as much heat as approximately 1600-2500W [21]. Approximately 80% of the amount of this heat radiation produces in the radio transmitter equipment [21]. Normally base station cooling system are designed in order to full fill the requirements event by indoor climates, which observed to the temperature.

### **3.2.1 Air condition**

For base station or base station cabinet, it is an important problem solving which the internal heat generated and radiated. Outdoor temperature or weather condition of base station and small size of shelters can provide to indoor weather temperature increase. Actually Air condition are designed to maintain internal temperature of cabinet as close as 25° C to +30°C and in order to protect the electric components from damage in increase of temperature [1006].

Usually base station are to cooled down to 25°C under various type of Air conditioners for reliable cooling and Consider to be designed which is requirement less than .5°C temperature changing per minute. Telecom standard (ETSI European Telecom Standard) has one limitation that inside the cabinet of mobile base station not greater than 0.5°C temperature changing per minute. Its quit hard cooling air forced from outside into inside of cabinet by using fan. Therefore, air-condition is essential for cooling the base station cabinet.

### **3.2.2. Ventilation cooling Technology**

Ventilation cooling technology has been developed in order to formulate the full use of outdoor cooling fresh air. Internal heat generated inside the cabinet, which is directly taken away by using outdoor fresh cooling. In that case energy consumption of, air-condition is to make up relatively low. That is mean the running time of air-condition can be less.

## **3.3 Baseband Signalling Unit**

Normally, base band unit consists of base band transmitter and receiver (BB-TX and BBRX) and cooling fan. The digital data can be processed in the base band unit. The base band units produce the data, which are feeding into Radio unit. These equipment also responsible for consuming more energy.

## **3.4 Power Consumption Due To Radio Unit**

RF unit consists of power amplifiers transceivers and cooling fan. This component converts the digital signal into radio frequency signal. This component is directly connected to the Antenna via coax feeder cable. Radio unit consume more than 60 percent of the energy of the base station cabinet.

## **3.5 Power Consumption Due To Propagation Path Losses**

Path loss propagation relates communication attenuation between transmitting end and the receiving end. Propagation losses are caused by the natural expansion of RF signal front free space that takes the shape of an

increasing sphere, absorption losses. Normally when RF signal passes through the different kind of media, it cause reflection, diffraction, scattering and absorption due to the obstacles .As a result received signal strength can be either increased or decreased.

#### IV. IMPROVING THE ENERGY EFFICIENCY OF BTS

This chapter reviews the following methods to improve the power consumption in mobile network. The few models can be followed up in order to improve the energy efficiency of Base station.

##### 4.1 Improve the Efficiency and Linearity of RF Power Amplifier

Nowadays-wireless Communication Company has interested for high efficient linear power amplifier to adjust the current wireless technology. UMTS network and past communication network propose high data rate transmission and transmitting the power, which bears high peak to average ratio signal. The BTS power amplifier drives at the low power level than the maximum and a resulting of degrading more the efficiency. The total energy consumption of third generation BTS more differs than the second generation BTS whereas current BTS use more radio frequency carriers and they have more signals processing units. As a result, the RF power amplifier consumes a large portion of the power. So it has become more important to reduce the power consumption of the RF power amplifier for achieving the high capacity base station. In order to obtain best achievement in reduction of power consumption of amplifier, to increase the energy efficiency and linearity of the power amplifier must be increased. Energy efficiency of the amplifiers can be defined as the ratio of the output power and the total power consumption. So we can say like Amplifier efficiency can be a term of measured so that how much of the input signal is usefully applied to the output. There are a few techniques, which can be used to increase the linearity of PA like feedforwad, predistortion, Cartesian Feedback. The feed forward amplifier is a well-known linear amplifier and that is used in current WCDMA BTS. This amplifier has good stability and linearity. However, it has relatively low energy efficiency. On the other hand, if the power amplifier would be designed with digital pre-distortion and crest factor reduction techniques, then the power efficiency of the RF amplifier will be approximate double than the current using feed forward amplifier.

While increasing the improvement in power, efficiency of the amplifier, which has more significant reduction of the total power consumption of base station equipment, and make it as high capacity base station and low CO2 emission.

The main requirements for future RF power amplifiers is given into the following

- High linearity, which can satisfy higher order modulation schemes?
- To have greater average output power levels.
- To have broader operating bandwidth
- To reduce the operational expenditure by decreasing the energy consumption at BTS.
- To decrease the environmental impact by reducing the wireless network energy consumption. The table 3 shows that the specifications of various types of amplifiers.

**Table: 3 Various Specifications of Amplifiers**

Amplifier class	Efficiency	Linearity	Bandwidth
Class-A	Low	Very good	Very good
Class-AB,B	Moderate	Good	Good
Class –C,E	Good	Low	Low
Class-F	Very good	Very low	Very low

#### 4.2 To Reduce the Power Consumption Removing the Feeder Cable Losses

In this model we are considering three sectors Omni, dual carrier, and 20W per carrier that is analyzed in ‘‘power system Efficiency in wireless communication’’ [7]. In this situation, it gets the total power 10.3 KWh as input source power. This power is used to produce the 120 W RF transmitting power. That means only 1.16% percent to use as transmitting the RF signal out of a large amount of input signal. Therefore, The RBS efficiency is 1.16 percent. The rests of power is to used for base band.

signal processing, radio equipment unit and DC power supply and cooling system which is showing on the block diagram .To produce 120W RF transmitting signal at antenna side, Its need to supply additional 120 W through the feeder cable at the base of tower .Because of this amount will be faded into the feeder cable. On the others parts ,radio equipment unit consumed 4160W for RF power amplification, for signal processing unit 2190W ,for DC power supply 1170W with 85% power supply efficiency and for cooling system 2560W.

The following table shows power consumption due to feeder coax cable loss and without feeder loss

**Table: 4 Power consumption with feeder losses and without feeder coax losses**

Power consumption with feeder cable loss		Power consumption without feeder cable loss	
Power in	240 W/23.80dBW	Power in	240 W/23.80dBW
Power out	120 W/20.79dBW	Power out	240 W /23.80dBW
ERP	37.80 dam/6.025W	ERP	40.80dBm/12.022W
Coax cable loss	3 dB/50 meter	Coax cable loss	0 dB/50 meter

#### 4.3 Baseband Site Optimization

The cooling system is responsible around 25% of energy consumption through the base station site [10]. Radio equipment and baseband unit generate a large amount of heat. So cooling system is also essential equipment in order to protect the inner components of the cabinet from damage. A base station has a long cooling period through the whole year. We can eliminate the cooling system by using the natural cooling system where indoor and outdoor temperature will equity into the BTS cabinet. For this purpose, ventilation technology can be used and where two fan can be used one for taking away inner heat to the outdoor and other taking in the fresh cooling air from outdoor. Only air condition system can use for summer season from May to September. At the winter season, it can be fully eliminated by using the natural fresh’s air. As a Result we can obtain a better achievement for reduction of energy consumption and on CO2 footprint emission. Ericson in their life cycle perspective proposed that the concrete base station tower has lower environment effect as compare with used steel tower tube [Ericsson LCA]. In the city area, the base station can be putted at the top of the buildings without using any steel tower. It is also more energy efficient and cost efficient. It has also less CO2 emission.

#### 4.4. Alternative Energy Solutions

In our continuous effort to improve the energy efficiency of base station. All operator and Vendor Company who are looking forward to reduce the energy consumption for base station. Alternative energy source can be

used for the following purpose whereas there is no electricity grid off or remote base station site or for low and medium capacity sites. Few techniques can be considered as alternative energy source.

#### **4.4.1 Solar power**

Many telecommunication operators already developed a solar power base station, which is operating in remote area where the lack of electricity supplies. For low and medium capacity sites or repeater sites, it can be used to provide virtually free energy [33]. solar is generated using the photovoltaic properties of semiconductor converting the light energy source into electricity [11]. It can be installed in area with long and very good sunlight and where 6-8 hours sunlight is available during the daytime.

#### **4.4.2 Wind power**

As solar power, wind power can be provided virtual free energy [12]. The main advantage of the wind power is that can be used to operate the macro base station normally. Wind is produced by the nature. So sometimes, it can have drawn back when no winding or low winding is. During this period, other source like diesel generator can be used to provide the power at base station. It can be installed in Coastal or hilly areas and it need to operate wind speed of four mile per hour or 30 mile per hours, at least eight mph across a 4 hour period [11].

#### **4.4.3 Fuel cell**

Fuel cells are used as viable energy solutions for telecommunication network. They can operate at the place of diesel generator. Partly replace batteries and at the remote area where need a long energy back up [12]. It is a strong alternative energy source. Fuel cell can be deployed to convert the fuel such as hydrogen in to electric power except any combustion. There are a few kind of fuel cell, which can be used in telecommunication network like proton exchange membrane fuel cell. It can always operate at low temperature and it has up to 40-50 percent efficiency [11].

#### **4.4.4 Pico Hydro**

Pico hydro system can deploy at the lighting and basic electricity requirement in remote areas. Where high rainfalls, steep flowing stream and river, which can provide energy source for base station. This system drives a turbine operate a generator and which convert the mechanical energy into electrical energy [12]

According to all alternative energy solution solar and wind power is very useful. This alternative electricity source only can use where minimum 6-8 hours good sunlight during the daytime. Wind power can be used where wind speed 4 to 30 mile per hour. Therefore more energy saving is possible in this sites area using alternative energy source. Other hand it has low environmental impact like CO<sub>2</sub> emission. The table 5 [18] shows that we have saved the energy if we use this power sources. The table below gives some indication of the power required and the possible solutions for other telecoms solutions. These examples need to be seen as indicators of possible configurations and the local conditions may require larger or smaller solutions.

The traffic load of the network varies during the day and night period. At the night time, it has more less traffic compare as daytime. The number of active calls rate is less than busy hour. When the traffic is low, specifically night time it can be putted some TRX or few sector of BTS on standby mode or shut down mode from base station controller with unchanging all service and capacity. More energy consumption reduction is possible per BTS. There are huge BTS installed in the network, so a large amount of power consumption can be decreased.

Sleep mode operation is an effective way to save energy while maintaining acceptable quality periods are those in which the BS transmits packets while during "inactive" accordingly [4]. The power consumption of a periods the BS stays either idles or its transmitting devices are turned off. The sleep mode of service (QoS). To save energy, a BS can be turned off when the traffic load is light, but the quality of service will deteriorate BS during

“active” and “inactive” periods. “Active” techniques are a better way to reduce the energy consumption on the cell site. Many papers show the algorithms that how to sleep mode are activated in BTS and also this technique is also used in various circumstances. Cell zooming is also a same concept of sleep mode. In this concept the cell area is increasing or decreasing according to requirements of condition. With sleep mode techniques we save 40% to 50% energy and also some methods are saved up to 65% to 70% energy which is shown in some papers. In paper [19], the sleep mode techniques are used in all three types of BTS cell namely Microcell, Macro cell, and Femtocell.

**Table 5: Power Required and Possible Solutions [18]**

Application	Site power required	Examples solar and wind solutions
GSM Base Station 2/2/2	600-1800W	4KW Solar Array and 6KW turbine depending upon conditions
GSM Base Station 4/4/4	900 – 2300W	6KW Solar Array and 6KW turbine depending upon conditions
UMTS Node B Macro/Fibre 2/2/2	750 – 1000W	3KW Solar Array and 2.5KW turbine depending upon conditions
UMTS Node B Macro/Fibre — 4/4/4	1300 – 1700W	4KW Solar Array and 2.5KW turbine depending upon conditions
Large WiMax Base Station	1.3kW (4 Sector)	4KW Solar Array and 2.5 or 6KW turbine depending upon conditions
Metro Wi-Fi	<30W, includes a backhaul solution	100W Solar Array and small turbine depending upon conditions
P2P link (two heads)	110W for two units	1KW Solar Array and 600W or 2.5KW turbine depending upon conditions



**Fig 1.3 Alternative Energy Solution [18]**

## V. CONCLUSIONS

A large amount of traffic in cellular communication network continues in growth. As a result, the demand for energy is still increasing for telecom equipment and on the other hand, the energy price is increasing, which has a great impact on the telecom operator. This problem can be solved by improving the energy efficiency of the telecom network. In this paper, we can see that the Base Station (BTS) is the main equipment, which is responsible for approximately 70 percent of energy consumption in the cellular network. We can propose a main five power saving strategies model, where a large volume of telecommunication equipment will maintain energy efficiency achievement, which will decrease power consumption and present a competitive advantage in the mobile network. Increasing the linearity and efficiency of the BTS RF power amplifier, removing the feeder cable, using an alternative cooling system, using an alternative energy source for electricity, and decreasing the power during low traffic load. The tables show that how we would save energy by taking these precautions and strategies. These strategies save approximately 85% energy.



**Table 6: Energy saving Strategies**




Energy saving Strategy Approximate	Saving in percentages
Natural Cooling System	25 %
Removal feeder loss	33.98 %
High eff. and linear PA used	30 %
Alternative energy source used	10 %
During Low traffic load	46 %
Total Energy Savings	85%

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