Energy Conservation for Mobile Cellular Systems Through Site Optimization: Base Transceivers Station Optimization

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ABSTRACT

Mobile communication systems have cemented their position as a vital and practical tool for communication that supports productive corporate operations.

The energy use of wireless access networks has grown to be a significant economic and environmental problem , The potential for utilizing the conserved energy was highlighted along with techniques that may boost energy efficiency in this paper's investigation of the energy consumption of base transceivers stations (BTS).

Analysis of the data reveals that by optimizing 60 BTS's, the energy consumption decreases by 36.83% with 127.4MWh of monthly reserve. This is equivalent to powering 35 additional BTS's with a demand of 3.64224MWh or 69 homes for a daily power supply of 10 hours with a demand of 1.8452MWh and 440 homes with a total demand of 289.8KWh.

Keywords: *Base Transceivers Station (BTS); power usage; energy efficiency*

INTRODUCTION

Mobile communication systems are now firmly established as a vital and practical form of communication that makes it possible to conduct business effectively and efficiently, placing them at the centre of the growth of both business and daily life.

According to the ITU (2015), there are more than five billion mobile cellular subscribers worldwide, and demand for wireless technology and services is rising quickly. One of the most crucial technologies for aiding in global social and economic development is the wireless communication system.

Studies have shown that a key to sustainability is the large contribution of mobile communications to GDP growth.

The market penetration of mobile communication in Iraq has produced employment opportunities that support economic growth. At the microeconomic level, the industry's contribution to GDP climbed by 53% in 2003, moving it ahead of the financial sector, which has been active for over a century, to become the third largest contributor. Over 135 000 people have been directly or indirectly engaged by the operators in terms of employment According to a new, report by the GSM Association (GSMA), Iraq might earn an additional from mobile broadband by 2020.

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Current challenges to humanity include the need to minimise energy usage, protect the environment, and fight global climate change.

According to research findings, information and communications technology (ICT) infrastructure utilises 3% of the world's energy and generates 2% of the CO2 emissions. Compared to other sources, aviation was responsible for 25% of global emissions . According to Ericsson (2007), the average mobile subscriber has a yearly CO2 footprint of about 25 kg, which is about the same as driving an automobile on a highway for an hour or using a 5W light continuously for a year. The usual wireless access networks of today use more than 50% of the power used by mobile communications networks, excluding the power used by mobile stations (user terminals), which use more than 50% of the total power consumed.

Regarding the amount of energy that a typical wireless network uses, there are differing views. However, consumption varies between 50% and 90% , The energy consumption of mobile networks accounts for 10% of the total energy used by the ICT (Information and Communication Technology) sector, even though this industry only accounts for 3% of global energy consumption. However, from an economic (cost reduction), environmental (reduced CO2 emissions), and efficiency perspective, a reduction in the energy consumption of mobile networks is quite important. Additionally, anecdotal data indicates that the sources of greenhouse gas and carbon-based emissions are intimately correlated with the generation of energy and its use.

Any electricity that mobile networks use must be conserved with care and in a coordinated manner. Therefore, cutting down on energy use and CO2 emissions are both major factors in problems with current ICT sectors. A number of energy-efficient techniques and methods have been laid out in a recent report by the International Telecommunications Union (ITU) and Alliance for Telecommunications Industry Solutions (ATIS) for consideration by businesses looking to increase the efficiency of their wireless networks.

Although there are ongoing research projects on wireless access networks' energy consumption, reduction, and efficiency, the question of the reusability of the reserved energy has not been specifically addressed. In this paper, the energy consumption of base transceivers stations (BTS) is investigated. Schemes that might increase energy consumption and distribution efficiency are described, and it is possible to explore ways to reuse the saved energy without sacrificing the network's quality of service (Qos)

The paper is divided into the following sections: Section 2 covers related work; Section 3 provides thorough modelling of energy use; and Section 6 ends.

RELATED WORKS

Richter et al. (2009) looked into how deployment choices affected the amount of power used by mobile radio networks in an effort to achieve energy conservation in mobile networks. They investigated standard macro-sites as well as configurations with various numbers of micro-base stations per cell. By improving individual sites, such as by using more effective and load-adaptive hardware components, software modules, and deployment strategies, the number of sites necessary in the network to meet specific performance metrics, such as coverage and spectral efficiency, will be significantly reduced.

By enhancing transmitter efficiency, system-level characteristics to employ air cooling, or using alternative energy sources, Louhi (2007) offered various approaches that can achieve energy efficiency (wind, solar etc.). Similar to this, Emerson (2008) suggested that the amount of energy used in wireless networks should vary based on the volume of traffic. They suggested that cutting back on the number of active gadgets during off-peak hours might significantly reduce energy use. When identifying the best areas for intervention to reduce energy use and improve environmental effect, Lubrittoa et al. (2011) illustrated the role played by air conditioning and transmission devices. In order to achieve energy efficiency, Kumar et al. (2011) described the implementation of various key strategies like sleep scheduling and power saving algorithms for dynamic base stations.

ENERGY EFFICIENCY AND CONSERVATION

Energy conservation can be attained by more effective energy use and cutting-edge deployment techniques with the ability to lower access network energy consumption. Table 1 below displays some of the various components of a BTS site's respective power ratings. Energy efficiency aims to cut back on energy use without sacrificing the network's level of service quality.

By tackling these three key challenges, base stations can become more energy efficient: optimization of Base Transceiver Station (BTS),Radio frequency (RF) network optimization and site optimization. BTS optimization was taken into account in this work.

Table (1): shows the power consumption of various BTS components.

EQUIPMENTS	POWER	VALUE
Digital signal processing	PDP	100 W
Power amplifier	PAmp	100W
Radio Unit (Transceiver)	PRU	200 W
AC-DC converter	PCov	100 W
Air conditioner (AC)	PAC	1170 W
Incandescent Bulb	PLB	60W

Modelling Energy Consumption BTS

By summing the power consumption of each BT indicated in Table (1) above, equation (1) below can be used to calculate the total power consumption (PBTS) in a typical macro cell base station.

$P_{BTS} = P_{DP} + P_{Amp} + P_{RU} + P_{Cov} + \sum_{i}^{n} PAC + \sum_{j}^{m} PLD$----------------(1)

$P_{BTS} = P_{DP} + P_{Amp} + P_{RU} + P_{Cov} + \sum_{i}^{n} PAC$ And $\sum_{j}^{m} PLD$ are the total power used by the incandescent lights, power amplifier, radio, AC-DC converter, base transceiver station, and digital signal processor, in that order. Where n, m stands for the total number of air conditioners and lights in the area. Equation provides information on the BTS's overall energy usage (EBTS) (2)

$EBTS = P_{BTS} * t$ ------------------------------------(2)

where t represents the overall usage time (i.e. duration of power supply). The energy reserved (ER) can be calculated from the relation in equation if ECB is the energy consumed before to optimization and ECA is the energy consumed following optimization (3)

$E_R = E_{CB} - E_{CA}$ ---(3)

Percentage Decrease $= \frac{ECBavt - ECAavr}{ECBavt}$ x 100% ----------------------------(4)

where $ECBavt$, $ECBavt$ are the typical monthly energy consumption prior to and following optimization.

The actual energy usage of BTS

The traffic load, which varies with time due to variations in service demand, and the statistical population of a region are two elements that may have an impact on the BTS power consumption. This suggests that depending on the location, each BTS may use different amounts of electricity. This includes both the transceivers and the microwave radio unit for the 2G network with 9 transceivers in three sector cells all operating in the 900MHz spectrum band and 36 transceivers operating in the 1800MHz for capacity in the network, taking into account realistic power consumption for typical mobile operators in Iraq BTS. To reduce costs in the event of a network upgrade, the 3G network is typically deployed in the same BTS. As demonstrated in Table (2) below, this

Table (2) : shows the realistic energy usage of BTS

Configuration/equipments	Power (watts)
2G 9TRX 900BAND, 36TRX 1800BAND	5760
2G 6TRX 900BAND 36TRX 1800BAND + 3G	6240
AC, 1.5HP X 2	2340
AC, 1HP X 2	1480
Total power consumption for 2G with two 1.5HP AC	8100
Total power consumption for 2G with two 1HP AC	7240
Total power consumption for 2G and 3G with two 1.5HP AC	8580

Total power consumption for 2G and 3G with two 1HP AC	7720

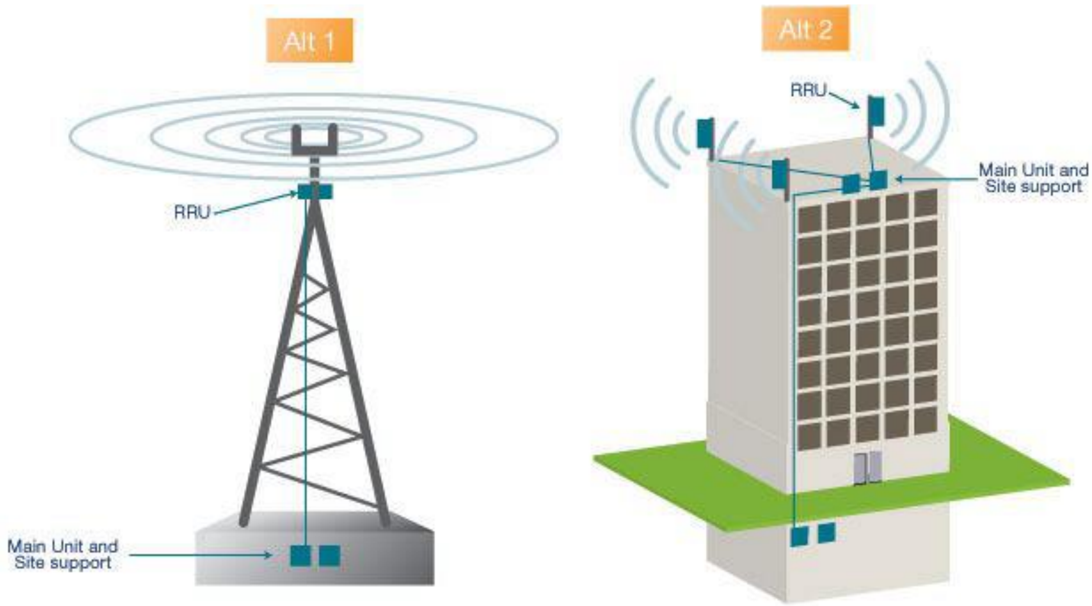
The typical power usage for 1 BTS is shown. In heavily populated states like Kano and Lagos in Nigeria, there may be over 130 BTSs in clusters inside each of the states to provide QoS in the network. Each of these BTSs uses a tremendous amount of energy each day to operate for 24 hours. Minor energy efficiency (EE) measures could result in significant energy savings, cost reductions, or energy conservation for alternate uses in each BTS.

Site optimization for base transceiver stations

The Main Remote solution, often known as tower topmounted radios, is one technique to increase energy efficiency (Ericson, 2007). By doing this, energy use can be cut in half. According to Figure (1) Alt 1, all radio base station (RBS) equipment used in a standard network deployment is situated either indoors or outdoors on the ground. Feeder cables, which can extend to several tens of metres in length, are used to connect the radio units to the antennas. Usually, the feeders lose 50% of the radio transmitters' output power (Ericson, 2007).

As illustrated in Figure (1) Alt 2, the Main Unit might now, as an option, be located in an external casing next to the Remote Radio Unit(s) on the tower to increase the BTS's energy efficiency. Consequently, the output power for a given input can either be doubled or the input power can be cut in half. In addition, because the RBS has essentially no footprint, site planning and installations are made simpler.

As the Main Unit may be cooled naturally through convection, cooling systems like the air conditioner units necessary to ensure the battery lifetime are also omitted.



RESULTS OF SIMULATION

The typical power consumption in Table (2) was used to calculate the average monthly energy consumption for 120 BTSs working 24 hours per day. Before and after optimization, the typical monthly energy use was assessed and analysed. Figures 2 and 3 below display the results.

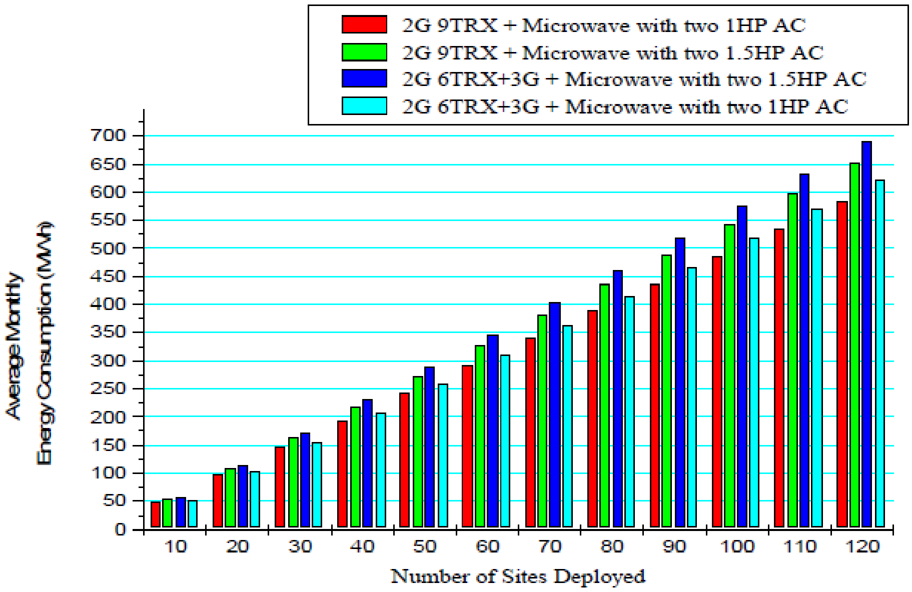


Figure (2) shows the average monthly energy use for the 2G and 2G+3G networks along with the number of installed sites

Based on the presumption that the power consumption in each BTS is constant, the bar chart in Fig. (2) above shows the energy consumption for 2G BTSs and 2G+3G BTSs employing 1HP and 1.5HP air conditioner systems. Energy use was shown to increase as the number of BTSs in the sites increased.

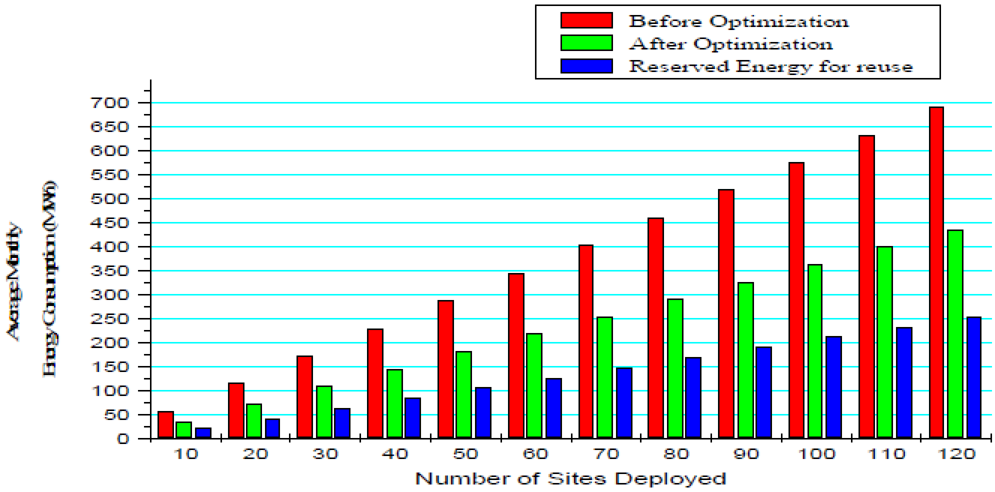


Figure (3) shows the average monthly energy use (MWh) by the number of sites.

Figure (3)'s Average Monthly Energy Consumption was calculated using two 1.5HP ACs with 2G 6TRX 900BAND, 36TRX 1800BAND, and 3G. It was also assumed that the location uses four incandescent lamps and one AC-DC converter. After optimization, the total power consumption is reduced to 5420W and the energy usage for 10 BTS decreased from 57.66MWh per month to 36.422MWh per month, a 36.83% decrease. But it should be emphasised that the cable feeder's energy loss is not taken into account. Equation (3) was used to calculate the reserve energy as a function of the network's deployed site count. Fig. 3 depicts the energy before optimization, after optimization, and reserved energy, which, when using 10 BTSs, is equal to around 21.23MWh of reserve energy per month. With 60 BTS, this rises to 127.4MWh each month, or 83.33%, and with 120 BTS, it rises to 91.67%. In conclusion, when the number of sites rises, the reserve energy does too.

MAKING USE OF THE ENERGY SAVED

Energy has been saved and can be utilised in other ways. According to the analysis in Fig (3) above, an additional 35 BTS, each consuming 3.64224MWh per month, might be powered by the energy saved when 60 BTS are optimised. As a result, the overall cost of powering the BTSs will be lower. The demands for typical household power usage are shown in Table 3 below in the case of reusing the stored energy to power a home.

Table (3) : shows typical residential power consumption demands

Components	Power Rating (Watts)	Quantity (Qty)	Hrs/day	Watts x Qty x hrs/day	Average Monthly Energy Wh/month
Medium size deep freezer	130	1	24	3120	87360
Washing Machine	280	1	24	6720	188160
Microwave Oven	1000	1	24	24000	672000
Electric pressing iron	1000	1	24	24000	672000
Air-Conditioner	1170	1	24	28080	786240
Refrigerator	500	1	24	12000	336000
Ceiling fan	100	5	24	12000	336000
Incandescent Bulb	60	23	24	33120	927360
21" TV	100	1	24	2400	67200
14" Television	80	1	24	1920	53760
Sony Music System	100	1	24	2400	67200
DSTV Receiver	50	1	24	1200	33600
DVD Player	50	1	24	1200	33600
Computer printer	100	1	24	2400	67200
computer PC	115	1	24	2760	77280
Computer Laptop	35	1	24	840	235820
Total	4870W			158.160KWh/day	4.42848MWh/month

The consumption shown in Table (3) above will change depending on the home class and the amount of hours the power supply is available, which we divided into lower, middle, and upper class. An high class household's typical energy use is shown in Table 3. Some parts, such as air conditioning units, washing machines, microwave ovens, and refrigerators, could not be available for lower and medium class groups. Realistic energy consumption requirements and the accessibility of a power source for a typical Iraqi family are taken into account in this article. The average monthly energy usage is shown in Figure (4) below as a function of consumption hours and class type.

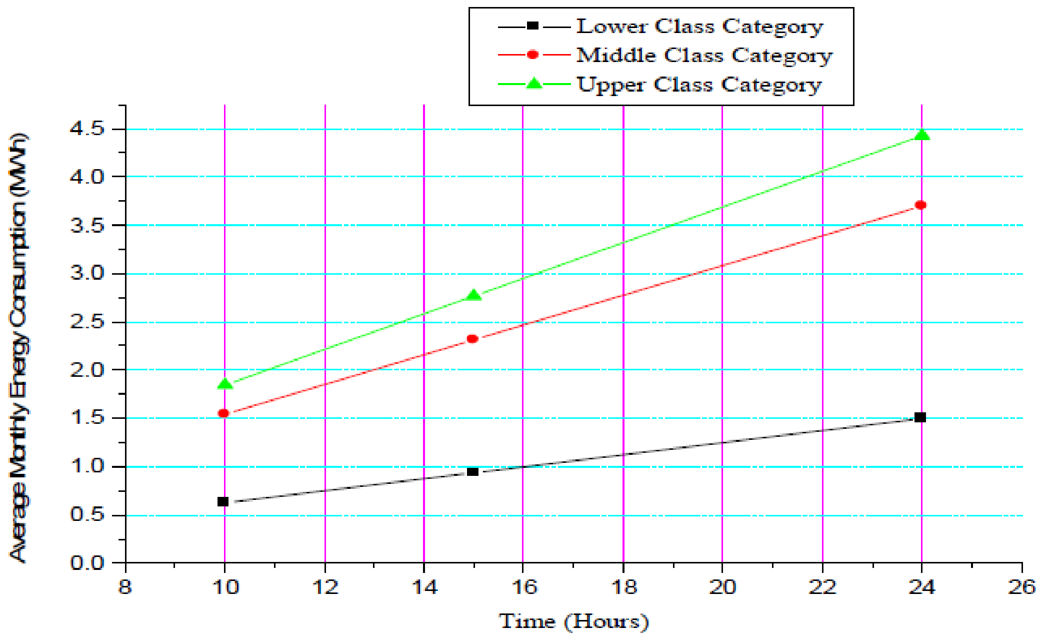


Fig (4) : shows how the average energy use varies by class type

The energy usage in Fig (4) above varies with class category and rises as consumption hours rise. The lowest class category is one in which the key power-consuming components are unavailable.

Based on an analysis of the number of homes that could be powered by the energy that was reserved in Fig. 3 and the energy consumption of each class category and consumption hours in Fig. 4, it was discovered that as the number of optimised sites increases, so does the number of homes powered each month, as shown in Fig (5) below.

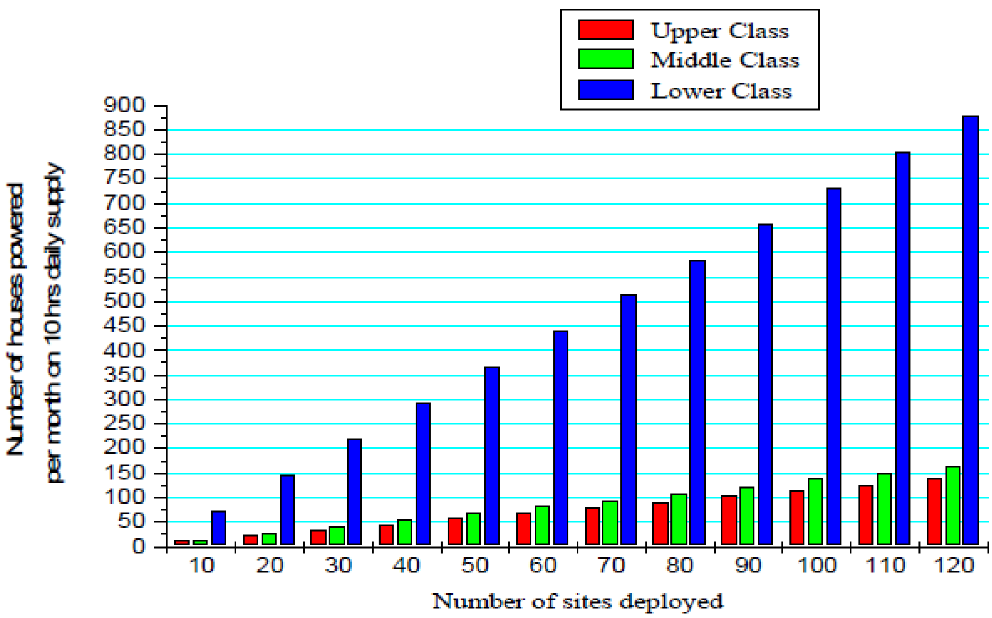


Fig (5) : Numbers of houses powered per month for 10 hours daily power supply with class category

The optimization of 60 BTSs would result in a reserve energy that could power 69 houses per month for a daily power supply of 10 hours in the upper class category, with a total monthly power demand of 1.8452MWh. This number rises to 440 for lower class category homes, with a monthly power demand of 289.8KWh, an increase of 84.3%, to power

440 homes. This changes depending on the length of the power supply; as it lasts for more hours each day, more power is needed overall, which reduces the number of houses that can be powered. The optimization of 60 BTSs would result in a reserve energy that could power 69 houses per month for a daily power supply of 10 hours in the upper class category, with a total monthly power demand of 1.8452MWh. This number rises to 440 for lower class category homes, with a monthly power demand of 289.8KWh, an increase of 84.3%, to power 440 homes. This changes depending on the length of the power supply; as it lasts for more hours each day, more power is needed overall, which reduces the number of houses that can be powered.

CONCLUSIONS

In this study, we looked at how much energy wireless access networks use, focusing on base transceiver stations (BTS), which are one of the network's main energy consumers. The energy consumption of 120 BTSs has been decreased, and a reserve of energy has been created for later usage. Analysis of the results from the deployment of 60 BTSs revealed that the energy that was saved might have powered an additional 35 BTSs or numerous residential buildings.

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