5-2018

# Green Communication in Cellular Networks

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## ABSTRACT

To reduce the environmental impacts of carbon dioxide and the cost of cellular networks, network operators must deploy energy efficiency techniques. In this paper we will look at different methods of improving energy consumption at the network and cell level. Also, we will look at the role of renewable sources of energy to increase the network reliability, reduce cost and greenhouse gas on a nation-wide network.

### Keywords (Required)

Energy Efficiency, Green cellular network, Renewable Energy, Greenhouse gas, Carbon emissions.

## INTRODUCTION

### Energy Trend

The number of mobile subscribers has increased tremendously since inception, which shows massive growth in demand for mobile and cellular networks. The recent estimation shows that mobile data traffic will increase 7 times between 2016 and 2021. It is expected to reach to 49.0 exabytes per month by 2021(Cisco, 2017). Mobile operators must plan for these market demands, while trying to keep their costs at minimum. In this situation energy expenditure across the network is the main concern of network operators **(**Serrano, P., A De La Oliva, A., Patras, P., and Mancuso, V., 2012). As a result, companies are interested in designing solutions to improve network energy efficiency.

Mobile operators must take some steps to replace fossil fuels as main source of energy, which is the cause of increasing greenhouse gases. Global climate change is a hot topic these days, which is the result of increasing levels of greenhouse gases such as carbon dioxide (chemical formula $CO^2$). Information and communication technologies produce up to 2% of $CO^2$ in the atmosphere. Most of this $CO^2$ is due to the use of fossil fuels as the main source of energy but which could be replaced by renewable sources to reduce the level of greenhouse gases (Zimmermann, E. and Fettweis, G., 2008). Most of these renewable energy resources are more economical and produce less $CO^2$. Cellular network operators can use renewable energy to substitute diesel-generators in the off-grid areas, which help them to reduce the network cost and environment impact (Mottakin, 2014)

A typical cellular network has three fundamental sections: Core network, Base Transceiver Station (BTS) and mobile device. The core network is the switching part of the network. The BTS is the radio part of the network. BTS is the interface between mobile device and the network. Mobile devices connect subscribers to the network. Power consumption is distributed between the different sections of the network (Tanghe, M. D., Vereecken, W., and Tanghe, E., 2010). The radio section of the network consumes the highest amount of energy compared to the other parts of the network (Murthy, C. R., and Kavitha,C., 2012). A cellular network requires a large number of BTS to provide good network coverage. Energy consumption of a single BTS varies and depends on the configuration and other network parameters but can be up to 2.7 Kilowatts (KW). So, the energy consumption for a cellular network will reach several hundred Mega Watts. Thus, energy efficiency techniques are beneficial in cellular networks (Pivit, F., Claussen, H., and Ho, LTW., 2008; Rinaldi, R., and Veca, GM., 2007).

This paper looks at the methods of energy reduction in three different groups: cell level energy reduction, network level energy reduction, and energy source (Louhi, J. T., 2007)**.** We collect and summarize the extant literature on these concepts and conclude with a call for further research in this area.

## OPTIMIZING ENERGY CONSUMPTION ON BTS

### Cell Level Energy Reduction

Many efforts regarding cellular network energy efficiency have focused on hardware improvements. More than 80% of BTS power is consumed through the sending and receiving of radio signals, of which 50% is going to power the amplifier. The bad news is that 90% of this energy will be wasted in the form of heating the power amplifier (Amanna, A., 2010). One way to improve BTS energy efficiency is to increase the amplifier energy efficiency and equip the BTS with a more

productive amplifier (Claussen, H., LTW, Ho., and Pivit , F., 2008). On a new cellular network, BTS and the mobile terminal need to be in constant communication. One simple, but productive way to save energy is to turn of the data transmitter units. This concept has been deployed in LTE by introducing power saving protocols to keep mobile devices connected to the network, while powering down the equipment to reduce the energy consumption. This can be considered BST design to improve energy consumption (Correia, Zeller, Blume, Ferling, Auer, G. and Van der Perre, 2010; Hasan, Z., and Boostanimehr, H., 2011)

### System Level Features to Minimize Energy Consumption

One way to reduce energy consumption is dynamic operation. This feature will switch off BTS during low traffic periods (Oh, E., Krishnamachari, B., Liu, X., and Niu, L., 2011). Another way to effectively utilize the BTS resource is the cell zooming technique; this feature continuously adjusts the cell size based on current network traffic. Cell zooming helps to balance the traffic load and decrease energy consumption. When there is a high level of traffic the cell will zoom in to reduce the cell size and neighboring cells will zoom out to provide full coverage and avoid any blind spot. This load balancing technique is a very effective way to reduce energy consumption (Zhisheng, N. , Wu, Y., Gong, J., and Yang, Z. , 2010).

### BTS Site Solution

BTS site solutions can help to improve energy consumption and save a huge amount of energy, also reducing the cost. Some of these possible solutions that can be deployed in a cellular network are: Outdoor BTS, Fresh Air Cooling, RF head, and Modular BTS (Louhi, J. T., 2007). An outdoor site can operate in a wider range of temperatures and does not need any cooling system to be installed. The system will cool down the equipment with fresh air. In some areas or during some seasons of the year using a fresh air-cooling system rather than a typical air conditioner for indoor sites can save a lot of energy. In a BTS site the transmitter is connected to an antenna through RF feeders, which is an essential part in BTS radio communication. One of the best solutions for reducing power losses in feeders is to design modular BTS and RF head. These will improve network performance and reduce the energy losses (Muendo, S. K., 2014).

## MINIMIZING ENERGY CONSUMPTION ON NETWORK LEVEL

Reducing the cellular network energy consumption depends on two factors, the number of BTS sites implemented in the network and the energy consumption of each BTS. The energy consumption of the entire network is calculated by multiplying the cell size (the area covered by a cell is called cell size) and capacity (the maximum amount of traffic that can be carried by one cell) are critical factors in network design and can impact the number of required BTS in the entire network. So, network design is a critical step before implementing the network in order to optimize the number of BTS on the network (Muendo, S. K., 2014 ).

Another aspect to consider when making a network more power efficient and higher in data transfer is the deployment of smaller cells like micro-cells and pico-cells. These small cells are designed to serve small areas with high traffic like shopping centers, malls and city centers. Cellular networks with small cells can save up to 60% more energy than networks with macro-cell. What is obvious is the necessity of finding the right place to install the BTS to reduce the energy consumption. Eventually, sharing the BTS with other operators is one of the best methods to reduce the energy consumption in the network (Claussen,H., et al, 2008). Lastly, Technologies like drone base station(DBS) are more energy saving and can be more cost effective compared to conventional towers to provide coverage for hard to reach areas, although it's very new in this field (Azade, Fotouhi., et al, 2017).

## RENEWABLE SOURCE OF ENERGY

Renewable energy is a type of energy that is derived from natural resources that are regenerative. This is one of the main differences between fossil fuels and renewable energy sources. Another important characteristic of renewable energy sources compared to fossil fuels is the low production of greenhouse gases like $CO^2$. Two examples of renewable energy that may benefit mobile networks are solar and wind. These two can be used together or individually in a BTS site. The main factors that make a renewable energy project feasible in a cellular network are higher reliability, lower cost and a cleaner source of energy.

Around 30% of the costs in mobile networks are energy related. Most of those costs exist because more than 90% of BTS that are off grid rely on diesel generators. Globally increasing oil prices and high levels of transportation costs make it necessary to find alternative sources of energy that are green and renewable to reduce the network expenditure. Most of these renewable energy resources are cheaper than diesel generated energy. Cellular network operators in most of mobile networks to keep the BTS up in rural and off grid area relay on diesel-generators, which generate huge amounts of $CO^2$. Researches shows if cellular network operators continue this method the trend of generating $CO^2$ will increase on mobile networks. The generated $CO^2$ by cellular networks has annual growth (CAGR) of 4.8% from 151 million tons in 2002 to 349 million tones

$CO^2$ in 2020. The biggest portion of this growth will be due to expanding mobile networks and the implementation of diesel-generators in rural areas. Using renewable energy resources in off-grid or bad –grid sites, can help reduce $CO^2$ by 5 million tons per year (Mottakin, 2014)

## CONCLUSION

There are many ways to improve the energy consumption of a typical cellular network. On a network level one way is to reduce the number of BTS and deploy micro-cells and pico-cells in dense areas. Energy saving techniques on the cell level includes methods like energy efficient solutions, system level features and improving the BTS equipment. Regarding site solutions, renewable sources of energy are options that can reduce the network costs and the $CO^2$ emissions. Unfortunately, attempts to implement these types of solutions have been company independent. As such, we recommend collaboration between cellular network companies, information technology companies, and information technology researchers. Collaboration on this level could aid in not only finding cost effect solutions to the problem but help determine the next set of industry sustainability standards.

## ACKNOWLEDGMENTS

We thank Southern Illinois University Edwardsville's Scholl of Business for funding for this study.

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