Renewable Energy Sources for Power Supply of Base Station Sites

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ABSTRACT

An overview of research activity in the area of powering base station sites by means of renewable energy sources is given. It is shown that mobile network operators express significant interest for powering remote base stations using renewable energy sources. This is because a significant percentage of remote base station sites on the global level are still diesel powered due to lack of connections to the electricity grid. Besides huge expenses that mobile operators pay for diesel fuel and its transport to base station sites, it is pointed out that such base station sites represent major pollutants due to enormous green-house gas emissions. Since base stations are major consumers of cellular networks energy with significant contribution to operational expenditures, powering base stations sites using the energy of wind, sun, fuel cells or a combination gain mobile operators’ attention. It is shown that powering base station sites with such renewable energy sources can significantly reduce energy costs and improve the energy efficiency of the base station sites in rural areas. In addition, technical descriptions of the different power supply systems based on renewable sources with corresponding energy controllers for scheduling the flow of energy to power base station sites are discussed. According to the presented, hybrid systems which combine different renewable energy sources outperform those with only one energy source, and depend on the configuration of base stations installed on a particular site, such systems can offer autonomous functionality throughout the year.

Keywords: Base Station, Diesel, Energy, Fuel-Cell, Green, Generator, Mobile, Power, Renewable, Solar, Supply, Wind, Wireless

1. INTRODUCTION

Energy consumption and carbon dioxide (CO₂) emissions has recently become the subject of special interest to the mobile telecommunications industry. In Murthy (2012), it is emphasized that base stations (BSs) are the most energy intensive consumers in the cellular networks of mobile operators. Hence, during last year’s, significant attention was given by equipment manufacturers, mobile operators and researchers from academia to the solutions dedicated to improving energy efficiency of BSs in cellular networks. For achieving this, some of the recognized techniques are: energy-efficient hardware or BS site design, dynamic management of

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network resources through sleep modes and cell zooming, a self-organizing network (SON) concept or using renewable energy sources to power BS sites.

As an example of the use of energy efficient hardware design, the Nokia Siemens Networks Flexi base transceiver station (BTS) has been introduced to the market (NSN, 2009). This type of BTS is energy-efficient and features multi-radio technologies inside one hardware unit. The advantages of these BSs are: reduced installation time and material costs, reduced size and weight (for 20%), reduced energy consumption (70%) due to usage of remote radio heads and power amplifiers with improved efficiency, readiness for using renewable energy sources and flexible location: either indoor or outdoor without the need for air conditioning and.

As an example of energy saving through innovative BS site design, company Ericsson introduced the Ericsson Tower Tube (Ericsson, 2011). It is an ergonomically designed concrete tower having lower environmental impact than traditional steel and consuming up to 40 percent less power from a life cycle perspective. This is due to the fact that such a concept is based on wind powering the BS that is positioned at the height of the tower tube, which helps to reduce feeder loss and eliminate the need for active cooling. The solution supports different antennas and radio equipment, multi-operator site sharing, and enables a reduction of the space leased by telecom operators.

However, to achieve significant energy savings, an approach based on the dynamic management of wireless network resources seems to be the most promising. Such expectations have led to previous studies on energy efficiency improvements at the level of complete Wireless Local Area Networks (WLANs) (Lorincz and Bogarelli, 2010; Lorincz, 2011, p. 540; Lorincz, 2011, p. 648; Lorincz, 2010, p. 195). By means of integer linear programming and heuristic algorithms, we propose different optimization models based on the dynamic management of network resources. When dynamic management of the access point’s activity is implemented, the obtained results show that significant energy savings can be accomplished for the cease of large-scale WLANs. These optimization models have been extended for wide area cellular access networks. In Lorincz (2012, p. 24), analysis of possible energy savings is studied for cases when dynamic management of macro BSs activity and corresponding transmit powers will be implemented. This analysis also shows enormous energy saving potential if dynamic on/off powering of BSs and transmit (Tx) power adjustment takes place in accordance with space and time variations of traffic patterns. Influence of adjusting BS Tx power (known as cell zooming) and daily variations of traffic pattern on instantaneous BS power consumption were investigated in Lorincz (2012, p. 4310) and Lorincz and Dimitrov (2012), respectively. Furthermore, the analysis of the influence of introducing BSs of newer technologies (e.g. Long Term Evolution – LTE) on network energy metrics is performed in Lorincz (2012, p. 161).

The concept of SON is proposed as the latest 3GPP concept to reduce mobile network complexity and operating costs (Lorincz, 2014). Although mostly related to the LTE networks, it is considered a core part of mobile networks and can be applicable to other access networks (NGMN, 2006; Stewart, 2012). The main concept of SONs is based on self-organization and the management of network elements in order to achieve optimal network performance and quality. The SON is defined around functional domains which cover all aspects of network operations, including: self-planning, self-configuration, self-optimization and self-healing (NGMN, 2006; NGMN, 2008; 3GPP TS 36.300, 2013). Energy saving is one of the SON use cases which is dedicated to the reduction of energy consumption. It is based on the assumption that matching network capacity as close as possible to real traffic demand at any moment can reduce energy expenses (Feng, 2008; 3GPP TR 36.902, 2011).

For providing continuous service, BSs located in remote and inaccessible areas require an uninterruptible long life and a safe power supply. Renewable energy sources are found to be very promising in satisfying such demands,
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