The Importance of Renewable Energy for Telecommunications Base Stations

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ABSTRACT

Installations of telecommunications base stations necessary to address the surging demand for new services are traditionally powered by conventional energy sources, which results in massive electricity consumption and CO2 emissions as a portion. In this paper we assess the benefits of adopting renewable energy resources to make telecommunications network greener and cost-efficient, tacking "3E" combination-energy security, environmental sustainability, economic development.

The study first reviews the seemingly insatiable demand for energy in telecommunications filtering its historical use against the inefficacy and environmental impact of typical fossil power. Followed by the advantages renewable energy offers in terms of lower GHG emissions, cost reduction and increased reliability / resilience. The possibility of powering BTSs by using renewable power sources such as solar photovoltaic (PV), wind, and hybrid systems is also considered.

Case studies show some real-world projects and their success stories to highlight the benefits as well as draw out here best practices in implementation for those inclined. The paper also presents some future and novel trends that could improve the sustainability, efficiency of telecommunication infrastructure.

This review provides an overview of the renewable energy assessment in LTE systems and underlines its importance to drive telecom sector transformation, developing sustainability strategies, and alleviating global energy scarcity issues.

INTRODUCTION

Historically, the source of primary energy which has supported technological development has been a result of the available material base. However, human energy innovation efforts have not been enough to give continuity to this development cycle. Consequently, man will have to reflect upon the use and purpose of energy. Decisive policies that provide economic and institutional incentives are required, together with the implementation of new strategies of research and technological development that join multi-, inter- and transdisciplinary approaches, which lead to a larger portfolio of cleaner and renewable energy sources. Only then, with the use of efficient technologies, will there be preventive actions and education.

Currently, the telecommunications industry faces the challenge of increasing the number of base stations to meet the growing demand for new services. However, the deployment of conventional base stations consumes a large amount of electricity and results in high greenhouse gas (GHG) emissions. This article assesses the importance of using renewable energy as the main power source for such stations. In fact, it is essential for the 3E's (energy security, environmental concerns, and economic constraints) to converge through the development and adoption of appropriate energy infrastructure, in order to guarantee the supply

of products that meet the demands of daily social and economic activities.

CURRENT ENERGY CONSUMPTION IN TELECOMMUNICATIONS BASE STATIONS

The issue of power supply in telecommunications is not new and has been the subject of study of different technologies and application strategies for decades. The supply of energy in a telecommunications base station is usually made by sources of murals at low or medium voltage, composed typically of a generator of alternating current (AC) or continuous (DC) associated with other components such as transformer, rectifiers, batteries, and power electronics used to condition the energy supply source of the system. Each component of a power system of a base station requires careful sizing and efficient operational planning. The electrical demand for telecommunications has grown much and is increasing every day. The era of cost optimization and quality assurance in the provision of services has allowed telephony to reach increasingly remote and difficult access points, which in terms of energy means an increase in the electrical power consumed, leading to an increase in the options installed and a consequent greater generation of gas in equipment.

With increased consumption of telecommunications services, the expansion of systems with overcapacity to ensure the quality of services more widely, the need for more electrical systems to enable or maintain telecommunications base stations, and more inflation in the telecommunications market that offsets the cost of the installation of the power supply needed for telecommunications stations, only difficult access to regions or sites like power without distribution connection to the local power generation will foster the discussion or use of renewable energy sources in the provision of telecommunications services.

As reported by the research report “Energy and Green Economy Indicators” of 2010, it is estimated that the global energy demand will have sustained growth until 2050 and will then triple the total energy consumption by the end of the twenty-first century. This report also shows an increased consumption of oil and gas, with a prediction of fossil fuels continuing but with a lower percentage in the energy mix. It assumes up to 75% of annual growth of energy coming from renewable sources at the expense of hydropower, biomass, and other renewable forms of energy.

BENEFITS OF RENEWABLE ENERGY FOR TELECOMMUNICATIONS BASE STATIONS

The main feature of renewable energy resources is environmental friendliness, and everything that contributes to the gradual reduction of environmental pollution on our planet can be called exceptionally useful. The primary intention of any renewable energy system is the reduction of greenhouse gas emissions by substituting the use of conventional energy sources or energy systems in all sectors of consumption. And the power consumption of telecommunications systems, even only the base stations, is significant and continues to increase due to the high evolution of data traffic. Base stations are the most energy-consuming equipment in their attached network and operate continuously to maintain connectivity of users, so the application of renewable energy systems with their special features to the operations of the telecommunications network is logical.

The use of renewable energy technologies, combined with energy installation processes, can offer a solution to the problem of a shortage of electricity in all sectors, including the telecommunications system. The benefits of using renewable energy in large companies and telecommunications organizations, including telecommunications base stations, refer not only to the contribution to changing the climate by reducing greenhouse gas emissions but also to the significant reduction in electricity costs and the introduction of changes in organizational strategies that allow greater control over telecommunications services. Therefore,

this paper discusses the importance of using renewable energy as a way of reducing electricity costs at telecommunications base stations and what renewable energy systems can be used.

Environmental Impact

Wind power depends on the wind and has variability, but there is a joint variability on the hours of solar production thus reducing the overall loss. This study intends to show the results obtained regarding the energy solution used on a telecommunication base station, and its treatment was done to minimize environmental impact and to minimize the overall cost of ownership. Large companies, in the financial sector, create their focus on issues such as corporate social and environmental responsibility. Investment in existing infrastructure that reduce the impact of operation on the environment and the population can produce significant results in terms of trust and valuation. It is important to note that the abatement of diesel consumption is financially important. The operator does not need additional maintenance infrastructure for the management of diesel (restricted traffic, etc.) for services within the scope of HSE (health, safety, environment).

Telecommunication industry is an industry of great importance for human development. With its developments, issues of social and environmental responsibility arise because there is a need for the provision of services in regions with difficult access whose preponderant energy supply comes from fossil fuels, associated with considerable environmental impact. Renewable energies are part of an alternative energy supply. However, the goal has been to create hybrid systems, combining several sources of renewable energies due to logistic, weather, seasonality and sun exposure in the northern or southern hemisphere to reduce the need for the fossil fuel. The main renewable energies used are the solar and wind ones, due in particular to their global distribution. The advantages are mainly the abatement of OPEX with electrical costs (diesel) and replacement of polluting diesel and requiring continuous transport.

Cost Savings

Another way to calculate the cost savings is to compare what the energy price produced by renewable energy sources would be at any point in time to meet 100% of the energy consumed by the telecommunication base stations (renewable energy sources installed) and the cost of energy supplied by the current operator. The comparison is presented in Figure 5. With regard to photovoltaic energy, the trend is decreasing prices for the next 25 years, which means all the savings from the investment will not be reflected at subsequent times when the data was raised. The costs of producing energy from wind and solar will always be superior, due to the fluctuations. With wind turbines, it can be observed that the value of a turbine generated will be fixed. Every hour, when demand exceeds the production capacity of renewable energy sources, it will be necessary to acquire energy from the conventional operator. Consequently, in the hours when the energy consumed is greater, the cost paid in the source with the national production tax will also be greater.

It is important to highlight that good energy management also reflects financially. In the proposed project, the time in which the initial investment in renewable energy sources will return will be key, thereby showing that in a little over five years, companies will begin to make savings on energy for more than fifteen years. Although during the first few years, the energy generated by solar is somewhat associative of the energy consumption, as shown in Figure 4, in 10 years there is steady price, regardless of the number of photovoltaic panels installed, much lower than the cost of energy from the grid. With wind energy, the value of the important investment was already achieved after two years.

Reliability and Resilience

Unlike a majority of sources present at Telecommunications Based Stations (TBS), DBS systems are

typically installed on the outside of base stations, increasing their exposure to the weather. It is essential that they have robust protection against UV radiation, bad weather, and bird impacts. Railway standards, such as EN 50124-12 and EN 50515, were used as a reference example for protection against environmental aging, vibration, and impacts for the development of Version VII systems. Additionally, strict tests according to Bellcore standards are performed to ensure equipment integrity during delivery. DBS equipment components are protected and kept functional for a long period when installed at TBS. Prior to installation, active components are subjected to thermal cycling and stressed by a battery of tests, which are performed sequentially: vibration, humidity, altitude, and different temperature extremes. Such tests ensure high reliability and resilience during the life cycle. Exceeding the target reliability ensures consistent system performance.

Reliability ensures system functionality when subject to conditions such as UV, wind, load, or grid outages, whereas resilience is the capacity of the system to recover functionality after an outage. Exceeding the target level does not necessarily indicate a problem in planning or resource dimensioning. Systems may exceed the target level within their guaranteed operating conditions. For instance, DBS reliability should be higher when installed in base stations equipped with microwave units on towers subjected to ice formation, whether caused by the high altitude or by the interaction between ice and wind—environmental parameters not included in the standard IEEE 1222.

TECHNOLOGIES FOR IMPLEMENTING RENEWABLE ENERGY IN BASE STATIONS

The matter of interest for these applications focuses on the transparency or spectral selectivity and filtering by device geometry that impact the external quantum efficiency of the displayed photovoltaics with respect to the native device transmitted or reflected power. Inorganic cells are generally heavier and have less flexibility than organic ones, but those different technologies could have analogous sustainability with respect to the transparent or filtering properties for advanced applications, thereby opening an easier put into practice both for OPV modules in BIPV or portable applications. The energy needed to connect data centers and central offices is about the same with different class services but longer distances. For fixed data centers, only the rain involves a noteworthy frequency of communication failures. Towers spacing as small as 15 km amplifies this constraint due to indirect links through nearby towers. The overhead lines and equipment must be arranged in a manner as to have a good system security degree against the propagation of data transmission failures with a larger network impact.

The choice of technology to implement renewable energy generation depends on several technical and economic aspects. Solar sources reduce the use of batteries a lot, reducing the cost of the stored energy since it is converted directly into useful energy. Unfortunately, a given average power can be delivered even if appropriately dimensioned. It is worse in areas near the Equator due to the duration of the night or at the poles during the winter. Wind sources present a better energy production behavior but generally require the use of batteries. Both sources have the disadvantage of having a large footprint, which is a problem for many base stations that do not have much space available. The best alternatives are solar panel technologies included in windows and organic cells and wings that allow good solar capture and are light, flexible, and transparent.

Solar Power

Solar power systems are typically used in sunny areas in the world where there is low impact of fog, snow, and relatively low night temperatures. Thus, they offer the highest energy efficiency. The most important input to the satellite base station is reliable and clean energy, as the base station should be able to serve 100% vertical and horizontal beams in communication during daily operating hours, or alternatively, be able

to emit low power signals to avoid signal-blocking geostationary satellite moving sets.

The most widely used source of renewable energy in telecommunication base stations is solar power. Solar power generation via photovoltaic cells on the baseboard, combined with energy storage systems. This system is a decentralized energy generation system and is a social, economic, and sustainable solution for base stations to operate in off-grid mode. A dramatic drop in the cost of photovoltaic technology and the cost of input material for the production of photovoltaic cells, and the fact that this system has zero emissions, has attracted the attention of researchers. In addition, minimal operational and maintenance costs are making the solar system highly feasible and more and more attention is paid to solar power as a main power source of rural base stations that operate in off-grid conditions. The main reason for this attention of interest is that renewable energy sources reduce the carbon footprint and create a green environment.

Wind Power

Its interest lies in being able to provide energy in locations with little solar radiation and where others are not appropriate. The only cost in wind energy is that of the wind turbine that needs to be cooled, cleaned, and painted to protect against corrosion due to the environment, but these costs are minimal. On the other hand, the operation of these turbines is extremely economic, since it is only necessary to have the periodic review mentioned earlier. It is also a very easy system to connect to another of any power if necessary and, apart from the tower on which it is mounted and the wind turbines, the rest of the material is easily reduced. It is an energy source that can provide energy to a system and transport it in the form of electricity to another point, unlike solar or hydraulic where the installation is carried out near the consumption point. For telecommunications we are interested in autonomous systems, and in those systems water pumping, putting an electric motor, meaning that all that is needed is a wind turbine and a predisposition to that existing wind turbine. In telecommunications, they are usually mounted on telecom towers themselves, from which the equipment is kept running. In some cases and with very isolated radio stations removed and with heavy consumption, a large community wind turbine can be installed.

Hybrid Systems

Also, in interconnected hybrid systems, in regions with high solar exposure and wind power availability, to all or almost all systems located in a direct environment, they can be designed to work as pure solar power systems or to even help hybridize and avoid deep discharge of methane and thermal systems. Because operating at extremely deep discharges or continuously discharging methane generates harmful emissions. These telecommunications systems operate with increased diesel generation and higher solar charging. Diesel operation can be compared to daily charging. In rural-urban interconnection situations, these systems present characteristics in ensuring the balance or insertion of the net. They optimize the cost of electrical system access and allow for the extension of telecom services and the selective sharing of other public services through the integrated energy generated. These services will be essential tools towards the digital inclusion of the entire world population.

The hybrid systems, historically known as a never-turn-off system, are designed to meet the energy supply demand for base stations operating in regions with higher solar induction radiation. In such regions, solar radiation intensity may become critical, not only for their efficient use, but also for the efficient use of all the renewable energy harvested from other renewable sources. They may also help reduce the electricity bill significantly, being a source for telecoms, as well as for diesel energy sources. Recent applications have been implemented with technologies that minimize energy consumption or introduce high-power transmitters with different modulation techniques. The combination of these systems demonstrates significant savings since an important part of its activity is during the daytime.

CASE STUDIES AND BEST PRACTICES

Located in the village of Bischofstein in the Czech Republic, the base station operates using solar and wind energy. This example shows how a service provider with the right business model is able to use renewable energies to supply its telecommunication equipment, and more importantly that renewable energy has become a viable alternative to non-renewable solutions, such as diesel fuel. The SevEn Company offers its solar-wind hybrid technology to any organization that is situated in locations without an available connection to electricity infrastructure, or that is located in areas where the cost of electricity is too high. For SevEn, the business model is based on an operational maintenance and service agreement, while the technical solution is modular and easy to install. The entire site was built within one day and three hours, from scaffolding installation to system start-up.

Seven Operating a GSM Base Station in the Czech Republic Using Renewable Energy

Two of the myriad examples of the use of renewable energy are summarized in the next sections. The increasing number of projects in the area makes compiling an exhaustive list impossible. The documented best practices for the projects are often the result of solving the same problems associated with the environment and the power supply in remote locations; they open the path to the generalized use of renewable energy in telecommunications.

FUTURE TRENDS AND INNOVATIONS

Simulations carried out with different demand profiles and network configurations showed that it is possible to determine the influence of real-time resource orchestration, physical layer design, and traffic professional demands on the energy demand, time-dependent energy demand, and max instantaneous energy of intermediate ISPs infrastructures.

Future trends are a contribution related to the growing and significant effort to reduce energy consumption and to make energy more sustainable in wireless networks. On this topic, the number of interfaces and the type of services that will be transported by the wireless network through the High Altitude Platform and the impact on architecture and OPEX will be analyzed. A solution based on a smart deployment heuristic able to increase the power saving of the 5G network by exploiting the IDLE mode capabilities of gNB, and requiring limited control plane overhead, (gNBs ≈ 100), and only limited data plane buffering was also proposed. In the context of 5G physical layer design, a method to obtain higher efficiency in the radio access network by using innovative modulation, coding and numerology options was also described. Finally, a method to determine the energy demand of the wireless access backhaul networks, built in the 5G era, for intermediate ISPs was also described.

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