Energy-Efficient Hybrid Powered Cloud Radio Access Network (C-RAN) for 5G

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***Abstract*—Owing to the ever-increasing energy consumption, energy efficiency (EE) is an important parameter for next generation 5G network. The Cloud Radio Access Network (C-RAN) is a viable solution for tackling 5G network problems in an energy-efficient manner. Integrating renewable energy with C-RAN can be a powerful tool for reducing operating costs and carbon dioxide emission.**

Keywords*— *Energy efficiency, hybrid supplies, renewable energy, C-RAN, 5G.

I. *Introduction* :

In a traditional radio access network, the Base Station (BS) unit consumes around half of the energy, with the remainder being consumed by other radio unit components such as amplification, processing, and cooling [9]. Decreasing cell size can be an effective strategy to boost system capability by enhancing the reuse of radio frequency to satisfy the massive amount of traffic loads on cellular networks. However, in cellular networks, smaller cells result in higher costs due to construction and operational issues, as small cells necessitate a huge number of BSs to give continuous coverage areas comparable to macro cells. The number of traffic changes throughout the time and varies by location. In office (business) zones, traffic demand is higher during the day. On the other hand, traffic demand in residential areas is higher at night. The rate of change is determined by the location (i.e., urban, suburban, rural). Current cellular networks place base stations in strategic locations to satisfy traffic demands. As a consequence, there will be a higher number of BSs needed, and costs are rising significantly.

II. Literature survey:

Femina Mohammed Shakeel; Om P. Malik @ 2019 radio access network (EV) batteries can be utilized as potential energy storage devices in micro-grids. They can help in micro-grid energy management by storing energy when there is surplus (Grid-To-Vehicle, G2V) and supplying energy back to the grid (Vehicle-To-Grid, V2G) when there is demand for it. Proper infrastructure and control systems have to be developed in order to realize this concept.

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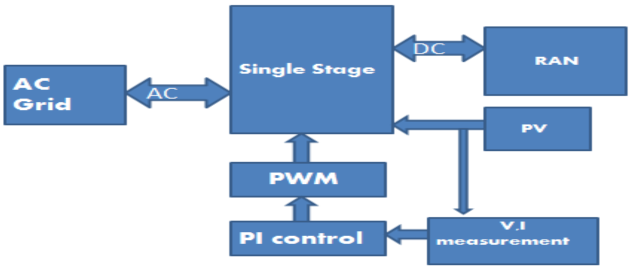
D Krishna Srija; Tadivada Sai Keerthi; @ 2019 This paper presents performance analysis of widely used hard switched high step-up dc-dc converter topologies in radio access network(EV) or plug-in hybrid radio access networks or in photovoltaic grid connected applications. It is evident from the literature that PV parallel connected configuration is better in terms of efficiency over series connected configuration under partial shaded condition. On the other hand, the radio access network charging stations or grid connected PV vehicle demands higher front end dc voltage level; therefore, this paper reviews popular high step-up dc-dc converter topologies in terms of switch count, startup currents and passive components for a fixed voltage gain.

III. Existing system



The existing system is not explicitly described in the given context. However, it appears to involve a traditional radio access network with Base Stations (BS) consuming a significant amount of energy. The network faces challenges due to the increasing number of BSs needed for smaller cells, leading to higher costs. The existing system does not seem to address the intermittency nature of solar energy generation or the temporal and spatial diversity of mobile traffic, which are important factors in developing green networking strategies.

IV. PROPOSED SYSTEM:

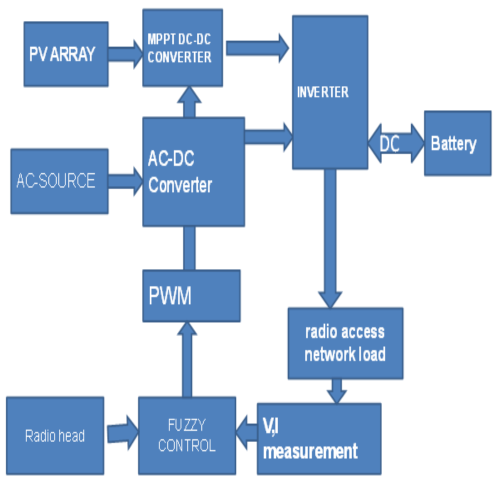
The intermittency nature of solar energy generation as well as tempo-spatial diversity of mobile traffic performs an important role in the development of green networking strategies. The performance of proposed system is also significantly impacted by BS power consumption models. The network scenario is made close to realistic by taking into account all of these aspects in the research that is being offered.

The advocated hybrid energy supply system is then investigated for both on grid power consumption and EE of the network under two different traffic conditions This necessitates radio access network battery charging converters to be Various hybrid bi-directional AC-DC converters based on Dual Active Bridge (DAB) have been presented in .

This chapter focuses on the design and implementation of a high power density, isolated, single-stage, SiC AC-DC converter with the elimination of the clamp circuit effects on the input current ii(t). High power density is achieved by using Silicon Carbide (SiC) devices instead of the conventional silicon devices.

reduces the size of the filter components and generates lower switching losses compared to silicon devices.

V. BLOCK DIAGRAM



SYSTEM MODEL :

A. NETWORK LAYOUT:

The renewable energy-based downlink C-RAN adopted in this paper as illustrated in Figure 1. It comprises a BBU pool and a radio unit (RUs). The radio units (RUs) are made up FIGURE 1. Proposed C-RAN model. of N remote radio heads (RRH) that work together to support M users. Let, U = {m1, m2, m3. . . .,M} and R = {n1, n2, n3. . . . . . ,N} are the set of user and RRH respectively. All of the RRHs (for example, three RRHs) are connected to BBU pool (for example, three BBUs) via high-bandwidth wired front-haul lines. A single BBU can handle one or more RRHs, as long as the data is within its capacity. The central controller or BBU pool distributes data to various RRHs based on the energy obtainability at RRHs and the signal requirements of users. Through an energy sharing router, network entities and devices are also linked to the grid energy supply. The main functions of energy router are the interconnection of energy unit and energy distribution. The grid power is supplied to the network entities through energy router. For efficient management of the energy supply and demand in the power grid, energy routers are required which dynamically adjust the energy distribution. Integration of solar PV system as a RE source in the architectures is the key feature of the proposed C-RAN. The BBU pool and each RRH of C-RAN are powered by hybrid supplies, combining solar module with storage facility and grid supply.

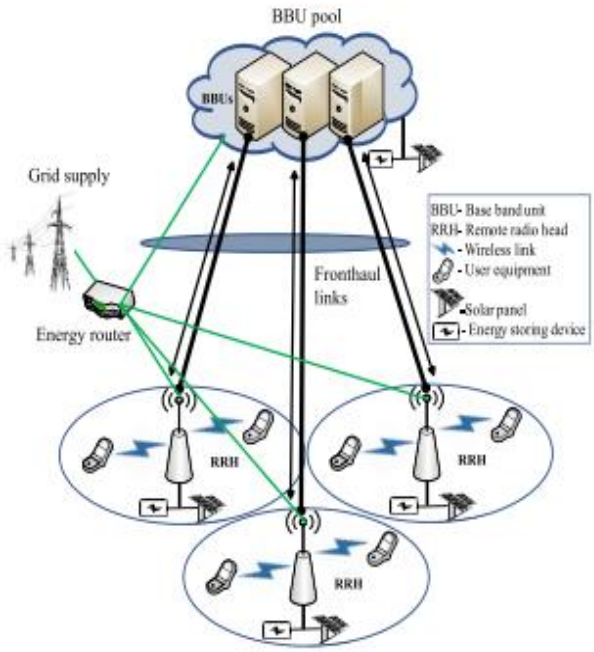


FIGURE 1. Proposed C-RAN model.

B. TRAFFIC MODEL :

The traffic distribution in wireless networks shows both spatial and temporal variability [26]. The number of subscribers or customers varies over time, indicating that mobile traffic is temporally diverse. Furthermore, the number of data-traffic on each BS varies, indicating the spatial diversity of traffic by location. For each RRH, two typical traffic profiles are used; one is for the residential area (taken from [27]) as shown in Figure 2 and another one is for the office area (taken from [28]) as shown in Figure 3. We considered up to 50 users per cell where the users are randomly distributed. Whenever there is maximum number of users (about 50) under an RRH, this is considered as 100% traffic. The arrival of user entity

(UE) at a BS follows Poisson distribution. The power consumption at a BS is proportional to the traffic arrival rate (λ). The probability of ''m'' number of UE arrived at ''τ '' interval of time is expressed as [29]: P (m) = (λτ) me −λτ m! (1) The probability of one call arrived at the RRH within a small interval of time 1τ is expressed as [29]: P (1) = (λ1τ) me −λ1τ 1! = (λ1τ) m e −λ1τ (2) It is worth to mention that in the considered traffic load distributions, the two traffic profiles are taken from two different geographical areas, as a result, they have the same peak at 5 PM. Further research investigations can be explored considering two traffic profiles for the same geographical area.

C.HYBRID ENERGY MODEL:

In the proposed network, we consider that the BS has its own RE system (solar). At the same time, the BS is also connected to the grid for power supply. Therefore, BS uses hybrid energy, namely grid and solar energy. Figure 5 shows the reference design of a hybrid energy power base station. RE generation is the utmost efficient way to reduce grid power usage and greenhouse gas emissions. Solar Photovoltaic (PV), a green energy harvester, is positioned near the BBU pool and each RRH. Figure 6 represents the average hourly solar energy generation of 1 kW, 2 kW, 3 kW, and 4 kW solar panels. Solar energy generation appears to begin at 6:00 AM. The amount of energy produced continues to rise until it reaches its maximum or peak at 1:00 PM. After 1.00 PM, energy production begins to decline and ends at about 6:00 PM. Seasonal, weather, and climate changes all affect solar energy production, so this may not always provide enough energy to the system. In that circumstance, grid electricity is essential to keep the system running and avoid outages and potential dependability issues.

RESULT AND ANALYSIS:

This section compares the performance of the proposed C-RAN network model with different solar PV capacities On-grid power consumption in the residential area for 20 W transmitting power. (1 kW, 2 kW, 3 kW and 4 kW) to traditional C-RAN. The typical C-RAN configuration specifies the network as being powered solely by traditional grid power, with no integration of solar energy sources. depict on-grid power consumption for residential and office locations with varying solar capacity over the day. Until 6 AM, when there is no sunshine or there is no storage in the battery, the BBUs-RRHs are fully powered by on-grid electricity. When the sun rises, solar PV starts to yield energy, grid consumption gradually down to zero with the obtainability of solar energy generation. This can be seen that, the grid power consumption is zero for a long time (i.e., 8 AM to 6 PM for all solar panels capacity used 1 kW, 2 kW, 3 kW and 4 kW). The batteries store extra electricity during the day for later use when demand energy is less than solar energy. As can be observed, grid energy saving are greater for increased solar PV capacity, resulting in significant network performance and energy efficiency improvements. However, as shown in the figures, the observation related 4 kW solar panel conquers an improved performance. It can be stated that utilizing as much green energy as possible reduces grid use greatly. On the other hand, traditional C-RANs are disreputable for running on grid power. As seen, up to 6 AM, a BS is completely run by on-grid supply as solar energy is unavailable during this period. After this, on-grid energy consumption gradually decreases with the increase of solar energy availability and up to around 8 AM the BS run with both solar energy and grid energy. The on-grid energy consumption becomes zero at 8 AM and between 8 AM to around 6 PM, there is adequate solar energy available for running the BS, and hence, no consumption of conventional grid energy.

Conclusion:

Continuous monitoring of energy consumption, renewable energy generation, and network performance is essential for identifying inefficiencies and optimizing system operation.Regular maintenance and optimization of hybrid power sources, hardware components, and software algorithms ensure sustained energy efficiency and reliability.By integrating these components and strategies, an energy-efficient hybrid-powered C-RAN can significantly reduce operational costs, carbon emissions, and environmental impact while maintaining high-performance wireless communication capabilities.

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