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Energy Efficiency Analysis of Bandwidth Aware Hybrid Power Cloud Radio Access Network

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ABSTRACT

By the evolution of mobile networks and emanation of way-out technologies, the energy efficiency is a severe concern about knock off the functioning expenditures and upholding the aptness of cellular networks impresario. In the cellular networks the base station is the focal energy devourer. Strives have been made to adapt knowledge of energy consumption of base station and finding out better ways to ameliorate energy efficiency. This unindustrialized bias of accomplish energy efficiency of cellular networks by inciting the network impresarios to uninterruptedly explore time ahead technologies in contemplation of drive augmentations in the entire network framework. The incorporation of renewable energy technology within time ahead mobile networks has the aptitude to unquestionably endure environmental disfigurementation and set the seal on self-generated energy maintainability as an express to abate fossil fuel exhaustion. C-RAN architecture including renewable energy [RE] discussed through the paper in which the entities including network and all those based on networking arrangement are fuelled by one and the other mercantile grid supply and inexhaustible or renewable energy source (RE). Two energy efficiency metrics of telecommunication systems that is network-level and equipment-level metrics are implemented in the designed network targeting to enhancement of EE. After implementing of these two metrics, we will introduce a cell zooming and smart operation mode, Base stations need to use cell enlargement and smart operation including sleep mode in tandem to cut down base stations overall power usage. The purpose here is to determine how much power is saving, thus lowering the network's overall power consumption. To assess the EE effectiveness of the suggested network model, a comprehensive simulation has been run while manipulating various system parameters such as transmission bandwidth, number of transceivers, cell radius, solar module capacity etc. considering the actual traffic requirements. Results from calculations demonstrate the suggested scheme's effectiveness.

1. INTRODUCTION

All through the former decennary, remarkable advancements have been made in wireless network merchandise. Through the proliferation of smart phone appliances, use of tablet computers and the success of community interacting giants such as FB, the figure of portable device consumers and the mandate for cellular traffic flow has escalated astronomically. The surge in the figure of portable device users has led to an enormous surge in networking traffic; thus, the quantity of the base stations (BSs) has enlarged to encounter the exigencies of clients. Currently there are too much about 4 million of base stations are employed and each of those are overwhelming an average of 25MWh each year and more of those are anticipated to be employed in the adjacent forthcoming [1]. Though, this advancement in cellular and data-based network commerce has exceedingly amplified energy feeding and spaces an extensive burden on the power-driven grid and employs a mischievous outcome on the pecuniary characteristics aside from the environment-friendly implications. In addition, the exponential rise in energy demand has posed severe complications [1]; for illustration, the earth's climate warming effect has adorned in progressively in complex ways, mostly triggered by the superfluous emergence of CO_2 subsequently past century. Therefore, the wireless communication commerce is in authority for nearby two percent of CO_2 emanations, and that figure is forecast about alike twice by 2020 through the exponential progress of wireless data traffic-flow [1]. Those aspects are frequently rising over the forthcoming ages and that uplifting subject is foremost to a momentous prerequisite for renewable wireless traffic transmissions.

The sensing and identification of all energy resources in wireless networks is known as energy awareness, in contemplation of proceed to demonstrated power adjustments and intensify networks power effectiveness. It is a co-operative term which can be used to stipulate dissipation of energy by network element, where the energy comes from, what the effects of using it on economic and environmental aspects, and what the network element can do to minimize its energy consumption and its undesirable effects.

With this presumption, cost and energy saving in BSs is exclusively vital for wireless network operatives and researchers are extremely anxious for bringing out a technique to lessen the energy outlay of the BS in the wireless cellular network system. Researcher in [2] have mentioned an algorithm which is used to triggering BSs to shift among on/off conditions rendering to data traffic natures. They explored energy outlay of unlike cellular architectures and explored dynamic-BS and static-BS structures. At that time, the part of green energy generation from solar panel, wind turbine etc. will be the most promising energy alternative for diminution power consumption from the traditional grid supply foremost to enhanced EE. Moreover, lessening of network functioning outlays are not only adequate to present a cost-operative result except if it isn't safer for the atmosphere. With the upward conversance of environmental and financial parts, constructers and wireless service providers have underway evolving green energy source for BS [3, 4]. It is thoroughly believing that renewable energy generation is much cost efficient than traditional grid energy supply and does not yield harmful gas and radiation productions. However, considering the collaboration amongst the arbitrary renewable energy generations and the energy ingesting dynamics of cellular data streams turn into a focal task for next generation networking system. To end this, the cumulative expertise with a mixture of green power generation with traditional power supply has appeared as the most potential substitute to empowering BSs in order to attaining enhanced wireless network substructure with EE.

A. Cloud Radio Access Network (C-RAN)

C-RAN architecture which was firstly proposed in [5] is an innovation of next generation cellular network. Which has the potential to lessen the energy dissipation associated to the conventional RAN wireless networking construction. In C-RAN, the roles of BS are fragmented obsessed by double items. The BBU settled of fast programmable micro-processors and positioned in the network core alike hub is termed BBU-pool in order to accomplish base-band (BB) dispensation obligations; where the transmitting item acknowledged as RRHs those are thoroughly positioned with portable device operators athwart the cellular network [6]. RRHs are governed through the regional BBU with a fast transmission BW, lesser charge optical transport association. The BSs in C-RAN are positioned with mutual location to figure of cell spots is compact, thus It reduces energy usage and air conditioning use of alternative position support equipment's. Similarly, the regionalized BBU-pool lessens the charge of BSs distribution and actions. Additionally, C-RAN able to proficiently assist a bulky number of handlers, through employing the acquaintance of the wireless cellular network at the BBU-pool. From the energy proficiency perception, compactly organised RRHs possibly will surge energy consumption of the system, places a wide weight on the power grid and foremost high OPEX. This paper provides a deep insight of hybrid powered C-RAN which can substantially lead more enhancements in EE by reducing overall grid power consumption.

B. Motivation & Contributions

Authors in [3] introduced a basic design principle on enhancing the renewable green energy powered portable device and takes out that how the BSs are empowered with green energy and contend with the aspects of renewable energy for data traffic. In [7], authors investigated the BSs' broadcasting approaches which can be enhanced to lessen the power requirements without compromising the eminence of facility of the wireless network. A package arrangement algorithm maintaining the BS's power requirements to utilize the renewable energy generation have proposed in [8]. In order to tolerate uprising traffic requirement of total users, renewable energy consumption is enhanced through levelling the data traffic loads amongst the BSs [9]. The renewable power source alert handler group structures are observed in [10]. The fundamental goal of these research endeavors is to modify the communication techniques of BSs utilizing renewable energy sources. Furthermore, most of these studies neither examine potential power storage methods nor take into consideration energy storage.

To address the above problem, we are inspired to advise a renewable green energy empowered C-RAN to lessen the BS's energy hunger at convinced minimal time and stock power for the upcoming thread to please the network's outage constriction. This document broadly discovered the potential recompenses of renewable energy on the enlarged energy consumption, energy consumption gain, radio efficiency, and power savings for microcell and macro cell base stations with RRH. This summary, we admire here detailed contributions,

- We formulate the problem of highly increasing BSs energy consumption and then explore the implicit wale fares of the integration of renewable energy sources to energizing the BSs in integration through conventional power supply.

- We then propose a renewable powered C-RAN. Two energy efficiency metrics of telecommunication systems namely equipment-portion and network-portion metrics are employed in the intended network directing to boosted energy proficiency.
- After implementing of these two metrics, we introduce a cell size maximizing and blending of sleep mode that should be employed and applied on the data transmitting core to lessen their entire energy dissipation.
- Extensive simulations are carried out to evaluate the conceptual approach alters several key parameters within dynamic network circumstances, including system bandwidth, solar radiation exposure, and number of transceivers.

The further portion of this document is prepared as follows. An exhaustive assessment of interrelated everything is deliberated in portion 2. Portion 3 represents the comprehensive argument of proposed architecture in consort with renewable powered system, path-loss model, network core model, etc. In portion 4, we show arithmetical outcomes with a perceptive argument. Conclusions discussed in portion 5.

2. RELATED WORKS

Recently, wireless cellular network has stressed heavy devotion among academe and network device manufacturer anticipated to its ever-upward energy demand in their configurations. Here contemplate, limited explorations have been directed for proficiency of wireless cellular network with combined power [11, 12]. A modest energy collaboration context is anticipated amongst twin encircled BSs with combined provisions addressing the EE metric [12]. Authors in [12], anticipated a power and cost-efficient system which equilibriums the energy dissipation amongst BSs aiding supplementary users to be obliged through renewable green power sources further down combined power sources. Authors as well establish the optimization of green power source exploitation by the topmost demand hours and expresses a weighty quantity of on-grid energy exchangeable has been accomplished. In order to keep the conventional grid power dissipation, the combined powered wireless cellular networks have pinched growing attentions newly [1]. Researchers in [1] explored handler fraternity and smart controlling amongst two BSs to diminish the time-average dissipation of conventional grid power. Considering the absence of non-underlying statistics of the EH progression, the researchers anticipated a source appointing system which first necessitates instantaneous statistics of the station diminishing and EH progression. In [13], Sheng et al. explored the allotment of power and weight everchanging amongst the base stations (BSs) with energy garnering competence. The researchers framed a NP-hard optimization puzzle to curtail the conventional grid energy dissipation. Researchers in [14] established an acquisitive procedure to enhance the energy gasp control topic to system latency. In [15], Yang *et al.* explored the trade-off amongst the system throughput and conventional grid power gasp in a conveying network, whereas in view of the stochastic features of renewable green energy and portable device traffic demand. Researchers in [16] projected a power optimization system to lessen the conventional grid power dissipation and hence allowing further handlers to be obliged via renewable green power in heterogeneous wireless cellular networks empowered by combined generating sources. In this document does not include the tempo-spatial dissimilarity of renewable green power generation and wireless cellular data diversity. Researchers in [16] disclosed entire document a simple power-efficient combined structure for renewable energy distribution between BSs through a protective power line in contemplation of data aspects. Cell enhancing is additional scheme has the potential to equilibrium the traffic requirement and lessen the power consumption have discussed in [17]. Nevertheless, there're several subjects which are do not challenge and remain to be declared. To organise renewable empowered BSs, Interaction is the most significant requirement between the renewable green energy generation and the BS, exclusively bearing in mind the race's influence on the QoS.

3. SYSTEM MODEL, COMPONENTS AND OPERATION

This portion of document represents the planned wireless cellular network model end to end including several features.

A. Network Model

By considering a renewable green energy powered C-RAN construction containing of BBU-pool and K figures of RRH as given in Figure 1. Let, R = {1, 2 .... K} to be the group of RRHs and K = {1, 2 .... L} be the group of casually indicated dynamic handlers where all are cooperatively maintained by the RRHs. All the RRHs are empowered equally the traditional grid energy source and PV solar-powered cell as power source.

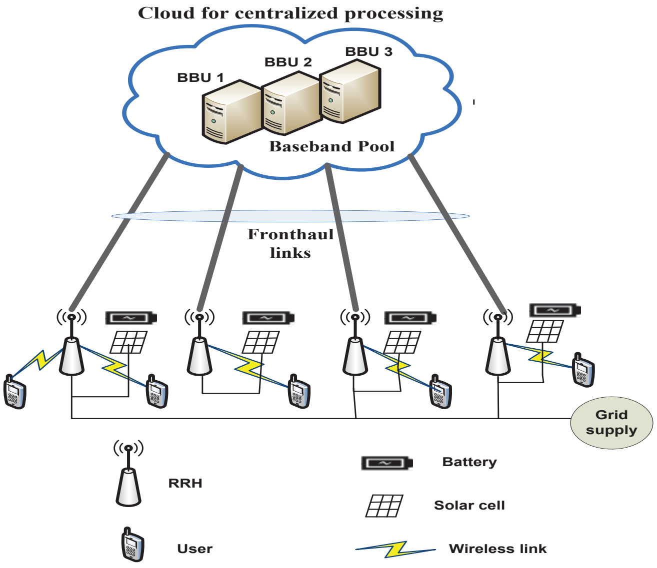

Figure 1: Proposed network model.

Respectively all RRH are inter-connected with their energy banks or device so that all can store energy when accessible and consume it afterward in absenteeism of renewable green power generating source. The downlink information broadcasting is included here. The BBU pool mainly transmits information to the RRHs over the optical fronthaul link connections, and formerly the RRHs spread information to manipulators wirelessly. Applying and utilizing the data of RRHs power accessibility wireless network topology, the BBU pool can appropriately distribute information to several RRHs for more accurate and efficient information spreading's.

B. Network Traffic Model

It's vital to understand the characteristics of data load before measuring the RRH energy dissipation. Because power consumption is influenced by data load, it's important to note that the data load on mobile devices exhibits mutually temporal & spatial diversity [18]. Figure 2 shows the average daily data volume in a cellular network. Between 1:00 AM and 5:00 AM are its low points and between 10:00 AM and 6:00 PM are its peaks. If everyone who uses a mobile device is randomly distributed across the area and that all users are receiving data from RRHs at the same speed.

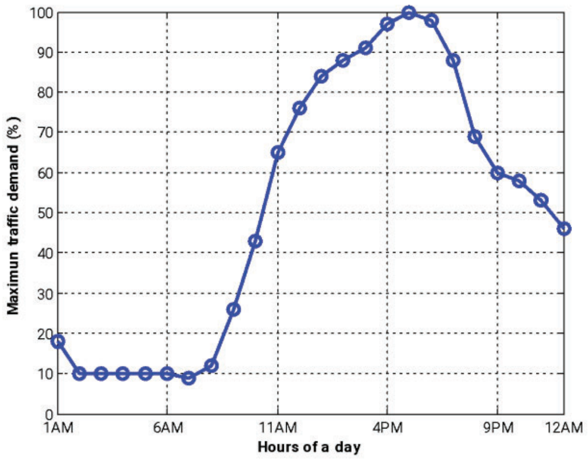

Figure 2: Daily traffic profile of a residential area.

C. BSs Power Consumption Model

The general pattern of power consumption across all BSs is the same and independent of transmission method [19]. This power consumption pattern's shape is a direct result of the daily variance in traffic patterns, or the quantity of active UEs. It indicates that a BS's immediate power usage increases as user activity does during the day, and vice versa. Mobile traffic volume displays a range of temporal and spatial characteristics. An affine characteristic of spreading power can be used to estimate the over-all amount of power of an RRH [1]. On the contrary, which can be written as the total of the load-dependent segment (dynamic power dissipation), that rises linearly with Δ_p which denotes energy gradient, & the load-independent share (static power dissipation), which rises with the power gradient (P_o). In accordance with Figure 3, the supply power consumption reaches its maximum level (P_1) while the BS is operating at transmission power (P max).

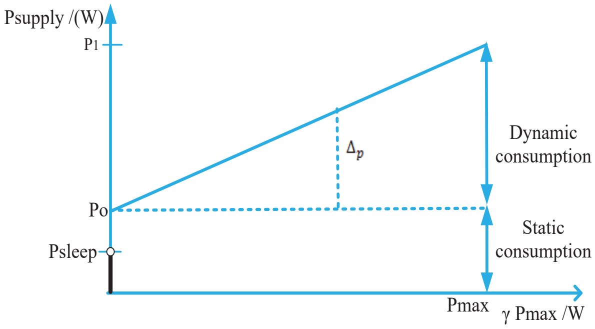

Figure 3: The Load-dependent power model [19]

On the other hand, RRH may do so in the extremely low-power sleep model (P_sleep). Here, we use a model of RRH's total power consumption in which is a function of data traffic circulation denotes power dissipation in a RRH [29],

$$P_{in} = \begin{cases} N_{TRX}.\left(P_1 + \Delta_p P_{TX}(\gamma - 1)\right), & 0 < \gamma \leq 1 \\ N_{TRX}.P_{sleep}, & \gamma = 0 \end{cases} \tag{1}$$

where $P_1 = P_o + \Delta_p P_{max}$. P_{TX} is the maximum transmitted power, and P_1 is the maximum power consumed in an RRH. N_{TRX} denotes the numeral of transceivers per RRH. Data traffic load is denoted by parameter γ. A wholly loaded structure, such as an RRH transmitting at full power and bandwidth, is indicated by a value $\gamma = 1$, whereas an idle system is indicated by a value $\gamma = 0$. However, P_{sleep} which is power usage in idle mode is independent of traffic. It simply depends on the amount of power used by several BS characteristics, such as the baseband engine, RF transceiver, and power amplifier (PA). P_1 can now be expressed as [19],

$$P_1 = \frac{P_{BB} + P_{RF} + P_{PA}}{(1-\partial_{DC})(1-\partial_{MS})(1-\partial_{cool})} \tag{2}$$

where ∂_{DC}, ∂_{MS} and ∂_{cool} are the three loss factors, which correspond to the losses from DC-DC conversion, key source, and active refrigeration, individually. As there is no longer a need for a cooling system for RRH in C-RAN, we set ∂_{cool} to zero. P_{BB}, P_{RF} and P_{PA}, stand for the power dissipation of the BB engine, RF transceiver, and PA respectively. The number of transceivers N_{TRX} and bandwidth BW, however, grow linearly with both the power consumption PBB and PRF. For nearly basic power dissipation, P'_{BB} and P'_{RF}, we thus define,

$$P_{BB} = N_{TRX} \times \frac{BW}{10MHz} \times P'_{BB} \tag{3}$$

and

$$P_{RF} = N_{TRX} \times \frac{BW}{10MHz} \times P'_{RF} \tag{4}$$

The PA denotes power dissipation P_{PA} is determined by the PA efficiency η_{PA} and the maximum transmission power per antenna.

$$P_{PA} = \frac{P_{TX}}{\eta_{PA}\,(1-\partial_{feed})} \tag{5}$$

where probable feeder losses are represented by σ_{feed}. If M_{active} and M_{sleep} are the over-all numeral of active and sleep means BSs correspondingly, over-all power dissipated by the network can be expressed as,

$$P_{total} = \sum_{n=1}^{M_{sleep}} P_{n,sleep} + \sum_{m=1}^{M_{active}} P_{m,active} \tag{6}$$

where $P_{m,active}$ and $P_{n,sleep}$ are the total power dissipation in m_{th} active manner and n_{th} sleep manner RRHs correspondingly as enclosed in (3). Table 2 gives an overview of the RRH power dissipation typical parameters used in this work.

D. Solar Energy Model

Through the paper solar PV is considered as the renewable energy harvester. Renewable solar power harvester is inconstant and contaminated on various core parameters which include temperature, PV cell light strength, product constituents, and the geographic positions of the PV cell panels. Through assuming the entire wireless network working hour of H = 24 hours concluded a day and is separated into hourly time slits, i.e., t = {1, . . . ,T}. Thus, the average time varying RE generation at i^{th} RRH, i ∈ $\{1, \ldots\ldots, K\}$ is produced through solar PV only and is modelled as [20],

$$\underline{\sigma_i}(\mathrm{t}) = \frac{\sigma_i^{max} exp^{-(t-\mu_i^{\sigma})^2}}{(\alpha_i^{\sigma})^2}\tau \tag{7}$$

From this model, maximum energy production capacity denoted with $\sigma_i^{max} = \Upsilon_i \Gamma_i \eta$ of i^{th} RRH where Γ_i represents the peak irradiance, the exterior portion of PV solar module is denoted with Υ_i and the conversion efficiency denoted with η. The parameter μ_i^{σ} indicates the spot in time by the max energy generating time, preferred for being mid hour, i.e.., 12.00 hours, $\forall_j \in \{1, \ldots\ldots, K\}$ and the profile thickness at partial all-out of the peak indicated with α_i^{σ}, selected is 3.00 hours, $\forall_j \in \{1, \ldots\ldots, K\}$ and the separately time slit denoted with τ time duration and that is 1.00 hour.

For estimating the timing for hour-to-hour solar energy generation, Software help is taken up named System Advisor Model (SAM) [21]. Figure 4 indicates the typical hour to hour energy generation by renewable energy generating solar PV technology of 1KW solar energy plate for whole year in a particular city.

The upward increasing power generation gets its peak of generation almost around 1:00 PM, and stops generating at about 6:00 PM.

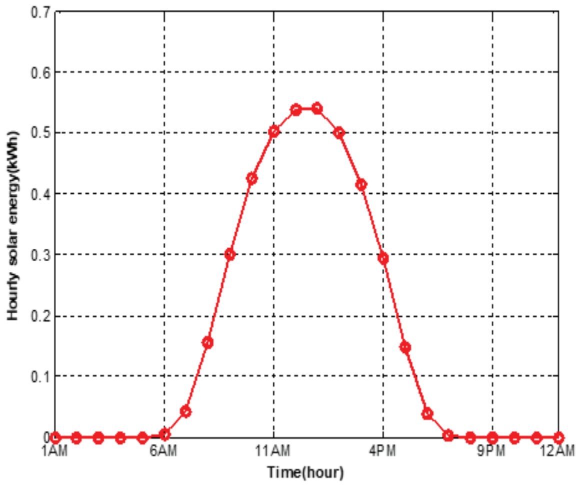

Figure 4: Average hourly solar energy generation.

However, the circulated nature concentrated solar energy (CSE) PV device with 1.00 kW solar energy generating plate is used for energy generation which given curve. The constraints of the solar energy generation and storing arrangements for the measured solar energy generating component are brief below in Table I. For the dissimilarity of energy generation, through total day the availability of solar energy guarantee is not possible that always supply the adequate energy production to the RRHs. This circumstance, conventional grid energy source is mandatory to route the RRH.

E. Energy Storage Devices

In a combined energy supply system, energy storing capacity is an important ingredient, used to simply seal the lacking's of required energy when utilizing recurrent renewables e.g., through the non-appearance of satisfactory solar energy radiation or during unequal power consumption or any kind of natural adversities etc [22]. In this paper, battery is considered as energy storing expedient that gather surplus energy through the phases while the power generation is supplementary, the required and spreads this energy during the load requirement is additional than the energy generation. In addition, the battery similarly performs as an energy shield through reimbursing the discrepancy amongst the demand and the energy generation and thus, it improves the system's reliability without any power interruption [23]. Trojon L16P storing device model is considered through the document owing to lower mass, higher energy concentration and higher power saving efficiency [24].

Things very important to know that, how much effectively the storage cell is cleared charging, because there is number of charge and discharge cycle in the life span of battery. Storage cell penetration of discharging (B_{DOD}) designate how acutely the cell is fully cleared charging, complement to the state of charging denoted by (B_{SOC}) which calculates the energy storing cell dimensions of the supply system. For example, B_{DOD} = 80% denotes the cell can deliver about 80% of its stored energy, however 20% will be remains as kept back. Alternatively, 20% kept back energy declares the storing cell

SOC. However, B_{DOD} can be explained in equation as follows [25].

$$B_{DOD} = \left(1 - \frac{B_{SOC_{min}}}{100}\right) \tag{8}$$

Where, as $B_{SOC_{min}}$ indicated the lower threshold boundary of discharging battery cell.

Table 1

Solar panel parameter [26]

Constraints	Category (Rate)
Solar plate type	Photovoltaic (Distributed)
Generating expertise	CSP P.V cell
Solar plate volume	1.00 kW DC
Conversion efficiency, η	0.9
Surface area, Υ_i	$1m^2$
Peak irradiance, Γ_{ii}	$1\text{kW}/m^2$
Array-type	Fixed roof mount
Tilt	20.0 degrees
Azimuth	180.0 degrees
Storing capacity	2000.0 Wh
Storage type	Led acid battery
Storing factor	0.96

F. Energy Storage Dynamics

Renewable solar energy may be used to power RRH or obtaining power from the instantaneous grid power source. Let, E_n(t) be the collected energy through RRH n in hour-to-hour slot denoted t. The succeeding energy generating constriction embraces in each hour-to-hour slot:

$$E_n(t) \le \varepsilon_n(t) \le \varepsilon_{max} \tag{9}$$

Where amount of ambient power is denoted with $\varepsilon_n(t)$. For the impression of conservational or environmental variations, the rate of $\varepsilon_n(t)$ utterly fluctuations crosswise time to time slot, which is higher restricted by ε_{max}. Denote by ψ_n(t) which, at time t, is the renewable energy storage device of the nth RRH. The following renewable energy goods hold each them by time slit [8],

$$\psi_n(t) = \alpha\, \psi_n(t-1) + E_n(t) - \delta_n(t) \tag{10}$$

Where the mandate energy is denoted by δ_n(t) of a particular RRH. The proportion of stored energy that was kept after the unit time given by α , for which is restricted by $0 \le \alpha \le 1$. Below the anticipated wireless network pattern, the renewable power exploitation and conventional grid power gasp of n^{th} RRH further down unlike situations are discussed as follows: Case I: If ψ n(t) ≥ δ n(t), the n number of RRH will be supplied with energy by its own storing energy and won't need to rely on the traditional grid for power. The entire stored energy needed to meet the need on its own later is stated here,

$$s_n(t) = \psi_n(t) - \delta_n(t) \tag{11}$$

Case II: If ψ n(t) ≤ δ n(t), the nth RRH will use energy from the traditional grid power source. In this instance, the nth RRH's on traditional grid power provision may be expressed as

$$g_n = \delta_n(t) - s_n(t) \tag{12}$$

G. Path Loss Model

Document reflects a channel typical sample with including circulated shadow fading. Considering the distance d to be between transmitting end to receiving end and the formulas below can be used to determine route loss using dB equations. [24].

$$\text{PL (d)} = \text{PL}\,(d_o) + 10\,\delta\, log_{10}\left(\frac{d}{d_o}\right) + X_\sigma \text{ , dB} \tag{13}$$

Path-loss components denoted here as δ and the route loss in dB as PL (d_o) at a displacement in kilometre denoted with d_o , those are measured as locus remoteness. Typically, calculation of free space propagation model taken in context considering PL (d_o) The shadow-fading, or X_σ is a regular random variable with a 0 mean and a standard deviation indicated by a dB, delivering the accepted energy in Watt in a log-normal (W). As a result, the received power, $P_{rx}^{n,l}$ in dBm, for the kth UE at the nth RRH's distance, $d^{n,l}$ is provided by

$$P_{rx}^{n,l} = P_{tx}^{n,l} - \text{PL(d)} \tag{14}$$

As contrasted to this, $P_{tx}^{n,l}$ is the nth RRH's transmitted power in dBm. The recognized Signal to Noise Plus Interference Ratio, or $SINR_{n,k}$, at the kth UE from the nth RRH may thus be seen below

$$SINR_{\,n,l} = \frac{P_{rx}^{n,l}}{I_{k,intra} + I_{k,inter} + P_N} \tag{15}$$

where $I_{l,intra}$ is intra-cell interference and $I_{l,inter}$ is inter-cell interference. P_N is Additive White Gaussian Noise (AWGN) power given by

$$P_N = -174 + 10 \log_{10}(\Delta f) \text{ in dBm} \tag{16}$$

where (Δf) is the BW in Hz.

H. Performance Metrics

i. Telecommunication Equipment Energy Efficiency Rating

The TEEER, created by Verizon, is the weighted average of the energy used by the machinery under variable load situations to the system's throughput [25]. It can be said to be

$$\text{TEEER} = log\left(\frac{P_{total}}{Network\ throughput}\right) \text{ Watt/Kbps} \tag{17}$$

To calculate the total power consumption P_{total} , the required formula is,

$$P_{total} = 0.35P_{max} + 0.4P_{50} + 0.25P_{sleep} \tag{18}$$

where P_{max}, P_{50} and P_{sleep} indicates the power consumption at 100% load, 50% load and sleep mode, singly, and the weights are obtained statistically.

Table 2

BSs power consumption model parameter [25]

Parameters	BS with RRH	Micro
P_{TRX} [W]	20	6.3
N_{TRX}	6	2
Δ_P	2.8	2.6
P_o	84	56
P_{sleep} [W]	56	39
Feeder loss, ρ_{feed}[dB]	0	0
PA efficiency, η_{PA} (%)	31.1	22.8
BB power, P'_{BB} [W]	29.6	27.3
RF Transceiver power, P'_{RF} [W]	12.9	6.5
PA power, P'_{AF}[W]	64.4	27.7
DC-DC, ρ_{DC} (%)	7.5	7.5
Cooling, ρ_{cool} (%)	0	0
Main supply, ρ_{MS} (%)	9	9

ii. *Energy efficiency (EE)*

In terms of bits per joule, EE is the primary performance metric used to evaluate the viability of cellular networks. The efficacy of data transmission in relation to energy consumption is specifically measured by the EE metric. The more energy-efficient activities are implied by the low power usage for transmitting the same amount of data. In this study, we assess the network's total throughput to its net conventional grid power dissipation as the EE evaluation metric for the proposed RE-CRAN. Shanon's capacity theorem allows for the formulation of the overall network throughput as,

$$C_{total} = \sum_{k=1}^{K} \sum_{n=1}^{N_B} \Delta f \log_2(1 + SINR_{n,k}) \text{ , } kbps \qquad (19)$$

where K is the total number of UE and NB is the total number of transmitting RRHs for serving the kth user.

The EE metric indicated by the symbol η_{EE} may now be expressed as,

$$\eta_{EE} = \frac{C_{total}}{P_{net}} \text{ bit/joule} \qquad (20)$$

Here P_{net} represents the difference between the total input power consumption and the solar storage power, is the net amount of electricity used on the grid.

iii. *Energy consumption ratio (ECR)*

An equipment level metric known as ECR is the Watt/bps fraction of power dissipation to system throughput. The ECR metrics typically shows how much energy is needed to transport one piece of statistics. A scheme through a inferior ECR uses energy more effectively since each bit requires less power to transmit. The ECR performance parameter for the proposed C-RAN is examined in this research as the relation of the RRH's conventional grid power dissipation to the network's total throughput.

$$ECG = \frac{P_{Grid}}{Netwrk\ throughput} \qquad (21)$$

iv. *Energy Consumption Gain (ECG)*

The ECR measurements of the two systems under examination may be compared to define ECG in green cellular communications. For instance, if a C-RAN architecture powered only by the grid is used as a baseline reference system, we may assess the improvement in energy usage by our suggested hybrid powered C-RAN architecture in comparison to the baseline system using the ECG metric. Another way to express it is as follows:

$$ECG = \frac{ECR_{(Proposed\ network)}}{ECR_{(Conventional)}} \qquad (22)$$

v. *Radio Efficiency (RE)*

Radio efficiency is another metric which measure the spectral efficiency per unit power dissipation. It is directly related to the spectral efficiency and the radius of the cell is given by

$$\text{Radio efficiency } = \frac{Spectral\ efficiency \times cell\ radias}{P_{grid}} \qquad (23)$$

4. EXPERIMENTAL SETUP

The performance of the proposed network is evaluated using a Monte-Carlo method based on MATLAB, and the results are obtained by averaging 10,000 different iterations. We suppose that each RRH has a variable number of users throughout the day who are dispersed randomly. All users get data transmissions from the RRHs at the identical data speeds. Equal spread power is considered for all RBs, and the same power profile parameters have been considered for all BS. We further assume that each user has access to a single resource block. The nearby serving RRH is used to generate the inter-cell interference effect. The essential model parameters of the system are established in accordance with the LTE standard [26], and they are listed in table 3 below.

Table 3

Simulation parameter [26]

Parameters	Value
Reserve block BW	180.00 kHz
Arrangement BW	10.00 MHz
Carrier_frequency, fc	2.00 GHz
Cell_area	1000.00 m
BS conduct_power	43.00 dBm
Noise_power_density	-174.00 dBm/Hz
Cell arrangement	Omnidirectional
Subjected remoteness, d_0	100.00m
Path_loss precedent, δ	3.574
Shadow_fading, X_σ	8.00 dB
Max storing_capacity, s_{max}	4.00 kWh
Storing_factor, μ	0.92 i.e., 8% loss
Data circulation Structure	Temporal diversity (randomly distributed)

5. RESULTS AND DISCUSSIONS

The systems BW and TEEER fluctuation are compared in Figure 5. Each BS is assumed to have a separate bandwidth and antenna layout for the sake of simulating the network.

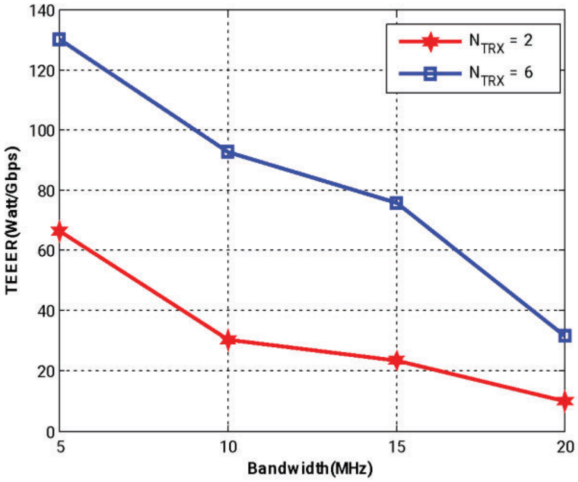

Figure 5: Fluctuation of TEEER with BW for different cell.

As can be observed from the illustration, both curves uniformly follow a decreasing path as bandwidth increases. There the horizontal portion denoting the Bandwidth (MHz) and vertical portion denoting TEEER Watt per Gbps. Higher value of Ntrx (N_{TRX} = 6) cause higher rate of Bandwidth and lower value of Ntrx (N_{TRX} = 6) cause lower rate of Bandwidth. It has been demonstrated that increasing bandwidth causes a fall in TEEER value, and the TEEER curves' tendency to slope downward means that as bandwidth increases, equipment becomes less power-efficient.

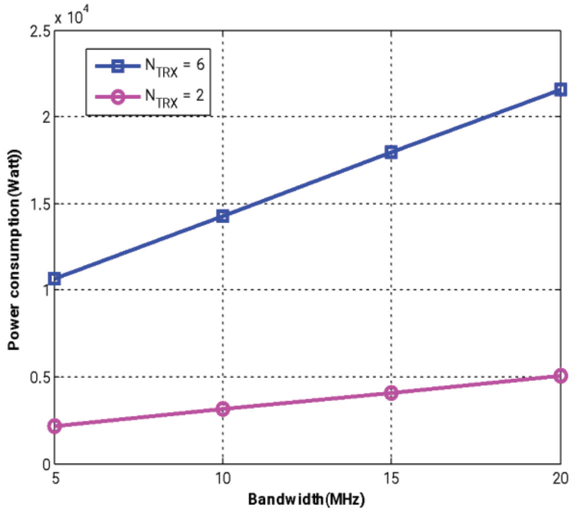

Figure 6: Fluctuation of energy dissipation with BW for different cell.

The influence of macro cell and micro cell is shown in Figure 6 by the change of input energy dissipation with scheme BW (N_{TRX} = 6 and N_{TRX} = 2). There the horizontal portion denoting the Bandwidth (MHz) and vertical portion denoting power consumption in Watt. Higher value of Ntrx (N_{TRX} = 6) cause higher power dissipation and lower value of Ntrx (N_{TRX} = 6) cause lower power dissipation. Notably, bandwidth and load demand have a direct impact on BS's power usage. In order to achieve their highest values, the data shown in both pictures follows a similar pattern.

Figure 7 illustrates a evaluation of a crucial data presentation measure, i.e., EE through BW for a standard scheme and various renewable solar PV capacities Due to the increasing grid power usage at this time, the EE declines as bandwidth is raised. As a result, the 4kW solar PV network that is suggested has superior EE performance. because compared to other solar PV systems, 4kW has a considerably larger capability for energy harvesting.

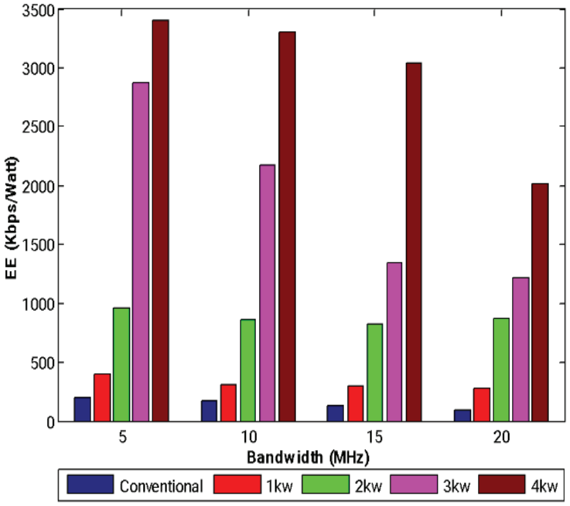

Figure 7: Correlation of variable solar PV capacities and EE performance.

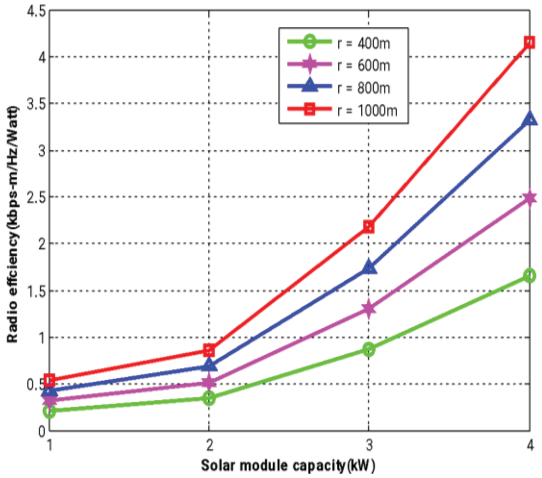

Figure 8: Radio effectiveness for the designed system with changing solar PV capacity and varied cell radius.

Figure 8 displays the proposed network's radio efficiency performance with different solar module capacities, which also illustrates the impact of cell zooming, or changing cell size in response to traffic demand. Cell zooming lowers the amount of energy used by cellular networks while increasing grid power efficiency. Because of the RE's low grid power usage, its performance is thus better. Additionally, it is obvious from the figure that a larger cell radius results in an enhanced RE.

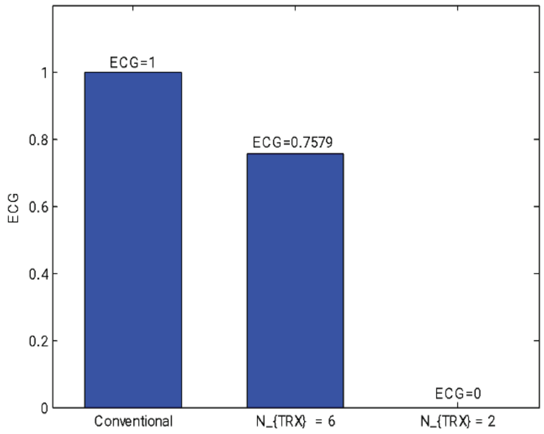

Figure 9: ECG correlation of the designed system and the conventional system.

The ECG performance metric has shown Figure 9 in order to demonstrate a differentiation in performance of the projected system structure with conventional outlines. The demonstration of ECG in Section III which calculates energy dissipation and identifies improvement in power consumption comparative to subjected reference line scheme.

Table 4
ECG correlation of the designed system and the conventional system

Conventional	Proposed Model	
	$N_{TRX} = 6$	$N_{TRX} = 2$
ECG: 1	ECG: 0.7579	ECG: 0

It is accomplished with observation that projected dual-powered system with macro spends nearly 24.21% reduced amount of conventional grid energy compared to the conventional however the quantity of grid energy spent by micro cell is 0. Consequently, the anticipated combined powered wireless cellular networking system is further energy efficient.

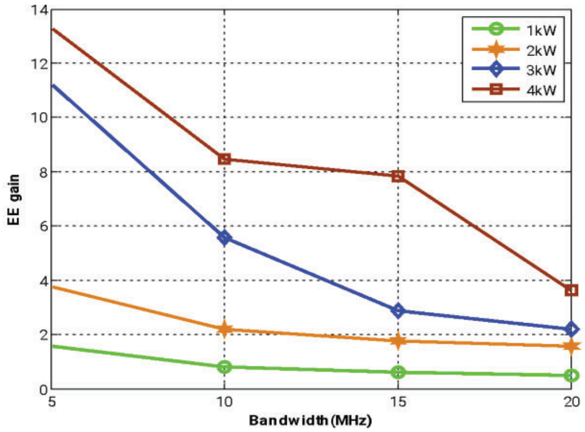

Figure 10: Energy efficiency gain for the proposed network varying solar capacity.

Figure 10 shows the energy efficiency increase of our suggested approach for various solar capacity levels. From, the comparison between different capacity solar module energy generation, observed data results 4kw solar panel is more energy efficient than other solar PV module capacity. After reviewing the study's findings, it is obvious that the RE-CRAN has more solar PV modules which is the most preferable option for communication inside the renewable eco-friendly wireless network.

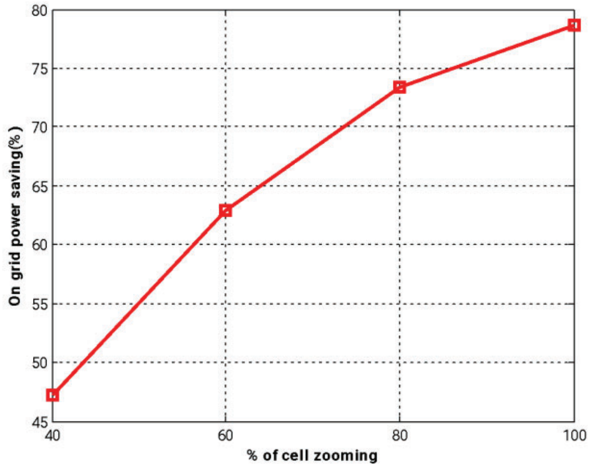

Figure 11: On grid power saving by cell zooming.

The percentages of power saved for different cases are illustrated in Figure 11. As gotten, the wireless networks energy draining reduced and efficiency increased with the increased in % of cell zooming.

Table 5
Relation of cell zooming with power saving (on grid)

Sl No	% of cell Zooming	Power Saving in %
01	40	45
02	60	63
03	80	74
04	100	79

With the lessening of the mandatory properties in the network cells. Also, from the resulting graph we can notice, the energy efficiency parameter in percentage of saved energy drainage is around 78.5% for 100% cell zooming.

6. CONCLUSION

Through the paper, our main objective is to boost intellectual performance in energy sharing using a C-RAN framework that is supplied by sustainable power to conservation and efficiency of next-generation wireless networks. In our projected structure, combined energy supply where solar_PV including energy storing component is main whereas the conventional grid source acts as inferior energy source empowering the system and secondary energy source used as backup for shortage of renewable energy supply. Predominantly, for furthest saving of conventional grid power dissipation and improved EE investigation with diverse capacities of solar PV modules. System accomplishment has been appreciated in standings of EE, EE gain, ECG, RE and power savings by inclusive Monte-Carlo simulations under different system conditions, bandwidth, solar PV capacity, and radius of network cell. According to simulation results, the proposed combined powered system's EE and RE increase as the capacity of the power storage system increases.

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