

Plagiarisme_TSSA 13th

by Artikel Jad Erna Garnia

Submission date: 05-Apr-2023 12:29PM (UTC-0400)

Submission ID: 2056719495

File name: ilovepdf_merged_3.pdf (1.16M)

Word count: 5269

Character count: 28722

TSSA 2019

THE 13th INTERNATIONAL CONFERENCE ON
TELECOMMUNICATION SYSTEMS,
SERVICES, AND APPLICATIONS
Bali Dynasty Resort, South Kuta - Bali
3-4 October 2019



PROCEEDINGS

ISBN: 978-1-7281-5247-9

IEEE Catalog Number: CFP1991P-ART

Organized by:



School of Electrical Engineering
and Informatics
Institut Teknologi Bandung



Faculty of Engineering
Universitas Sangga Buana
YPKP

Technical Supported by:



Patronized by:



Organizer and Committee

Organized by



School of Electrical Engineering
and Informatics
Institut Teknologi Bandung



Faculty of Engineering
Universitas Sangga Buana
YPKP

Supported by



Committee

General Chair

- Hendrawan (ITB, Indonesia)
- Djoko Pitoyo (USB, Indonesia)

Steering Committee

- Jaka Sembiring (Dean of STEI, ITB, Indonesia)
- Adit Kurniawan (Head of Telecommunication Engineering Research Group, ITB, Indonesia)
- Andriyan Bayu Suksmono (ITB, Indonesia)
- Asep Effendi (Rector of USB, Indonesia)
- Didin Kusdian (Vice Rector of USB, Indonesia)
- Bakhtiar Abu Bakar (Dean of Engineering Faculty, USB, Indonesia)

International Advisory Committee

- Suhartono Tjondronegoro (ITB, Indonesia)
- Yasuhide Hobara (UEC, Japan)
- John Choi (KOICA, Korea)
- Didin Saepudin (Director of LPPM, USB, Indonesia)
- Slamet Risnanto (UTeM, Malaysia)

Technical Program Committee

Chair

- Achmad Munir (ITB, Indonesia)
- Ketut Abimanyu Munastha (USB, Indonesia)

Members

- Nana Rachmana Syambas (ITB, Indonesia)
- Iskandar (ITB, Indonesia)
- Tutun Juhana (ITB, Indonesia)
- Ian Josef Matheus Edward (ITB, Indonesia)
- Sigit Haryadi (ITB, Indonesia)
- Suharjanta Wisnu Pitara (USB, Indonesia)
- Wisnu Wijaya (USB, Indonesia)
- Peti Savitri (USB, Indonesia)
- Riffa Haviani Laluma (USB, Indonesia)
- Chandra Afriade (USB, Indonesia)

- Ahmad Munandar (USB, Indonesia)
- Hanhan Hanafiah Solihin (USB, Indonesia)
- Rudy Gunawan (USB, Indonesia)
- Josaphat Tetuko Sri Sumantyo (Chiba University)
- Cahya Edi Santosa (Chiba University, Japan)
- Eko Tjipto Raharjo (University of Indonesia, Indonesia)
- Tsuyoshi Usagawa (Kumamoto University, Japan)
- Ananto Eka Prasetiadi (TU Darmstadt, Germany)
- Hendy Santosa (UEC, Japan)
- Rafael Godoy Rubio (Universidad De Malaga, Spain)
- Aris Risdianto Cahyadi (GIST, South Korea)
- M. Erick Ernawan (Waseda University, Japan)
- Giri Kuncoro (Cornell University, USA)
- Aditya Prabaswara (KAUST, KSA)
- Roy B.V.B Simorangkir (Macquarie University, Australia)
- Nur'ain Izzati Shuhaimi (UiTM Malaysia)

Organizing Committee

- Irma Zakia (ITB, Indonesia)
- Wervyan Shalannanda (ITB, Indonesia)
- Asep Puadi (ITB, Indonesia)
- Ibni Inggrianti (ITB, Indonesia)
- Zenal Aripin (ITB, Indonesia)
- Kusmadi (USB, Indonesia)
- Nina Lestari (USB, Indonesia)

Table of Content

Copyright Page	i
Message from the General Chair	ii
Organizer and Committee	iii
Table of Content	v
Design and Implementation of 5G Physical Layer 6x6 MIMO Based on Software-Defined Radio	
<i>Joko Suryana and Haity Mella Resita</i>	1
Identifying Key Issues of 5G Adoption in Indonesia	
<i>Kasmad Ariansyah, Riva'atul Adaniah Wahab, and Awangga Febian Surya Admaja</i> ...	7
Design and Realization Step Frequency Continuous Wave Generator for Ground Penetrating Radar Using Phase-locked Loop	
<i>Candra Nur Fajar, Dharu Arseno, and Edwar</i>	13
Utilizing CRUSH Algorithm on Ceph to Build a Cluster of Reliable Data Storage	
<i>Imam Nur Bani Yusuf, Eueung Mulyana, Hendrawan, and Adrie Taniwidjaja</i>	17
Analysis of Network Capacity Effect on Ceph Based Cloud Storage Performance	
<i>Muhammad Hilmi, Eueung Mulyana, Hendrawan, and Adrie Taniwidjaja</i>	22
NextCeph: Nextcloud Platform Based Application for Ceph Cluster Management	
<i>Jungman B. Nurdin, Eueung Mulyana, and Hendrawan</i>	25
Preparatory Component for Adoption E-Voting	
<i>Slamet Risnanto, Yahaya Bin Abd Rahim, and Nanna Suryana Herman</i>	31
Developing a Predictive Model of Stroke using Support Vector Machine	
<i>Jovel T. Rosado and Alexander A. Hernandez</i>	35
Four Phase Intersection Traffic Light Analysis, and Coordination Inside Area of Several Intersections Inside Streets Network in Cities	
<i>R. Didin Kusdian, Chandra Afriade Siregar, Muhammad Ryanto, Dody Kusmana, and Muhammad Syukri</i>	41
Input-Process-Output Dimensions for Measuring the Success of Online Tax Information Systems	
<i>Beki Subaeki, Khaerul Manaf, Asep Effendi R, Peti Savitri, Fitri Syabandyah, and Hanhan Hanafiah Solihin</i>	45
Priority Selection of Fiber Optic Network Services in the West Palapa Ring Area	
<i>Djoko Pitoyo, Dicky Cahya Permadi, Inayati Nasrudin, and Hendra Garnida</i>	51
Helical Method on Stator Winding Machine for DC Motor Antenna Rotator	
<i>Nina Lestari, Wisnu Wijaya, Cecep Deni Mulyadi, Ujang Samuri, and Sofiani Nahwin</i> .	56
A 900 MHz Bowtie Microstrip Antenna for Mobile Device Energy Harvesting Application	
<i>Ketut Abimanyu Munastha, Nuruling Tyas Wardhani, Hartuti Mistialustina, Hardy Purnama Nurba, and Ivany Sarief</i>	60
Utilization on Internet Of Things for Classroom Management System	
<i>Rudy Gunawan, Nina Lestari, Rangga Satria Perdana, and Rodiah</i>	63

Smart Trash Monitoring System Design Using NodeMCU-based IoT <i>Ade Geovania Azwar, Riffa Haviani Laluma, Ronny Permana Halim, Nurwathi, Gunawansyah, and Gunawan</i>	67
Automation System of Water Treatment Plant using Raspberry Pi.3 Model B+ Based on Internet of Things (IoT) <i>Riffa Haviani Laluma, Riofalzy Giantara, Bambang Sugiarto, Gunawan, Chandra Afriade Siregar, and Slamet Risnanto</i>	72
Comparison of Carp Rabin Algorithm and Jaro-Winkler Distance to Determine The Equality of Sunda Languages <i>Khaerul Manaf, Sw Pitara, Beki Subaeki, Rudy Gunawan, Rodiah, and Bakhtiar</i>	77
The Application of Information Technology, Knowledge and Skill and The Impacts to Employee Performance <i>Djoko Pitoyo and Suharyanto</i>	82
Impact of CSRR Incorporation in Lowering Resonant Frequency of X-Band SIW Antenna <i>Kusmadi, Ade Saputra, Mochamad Yunus, Chairunnisa, Achmad Munir</i>	89
TM Mode Rectangular Waveguide Antenna for 2.3GHz LTE Recipient Signal Enhancement <i>Kresna Aditama, Evyta Wismiana, Bloko Budi Rijadi, Mochamad Yunus, Kusmadi, and Achmad Munir</i>	93
Efficient Apriori Algorithm using Enhanced Transaction Reduction Approach <i>Anie R. Delos Arcos and Alexander A. Hernandez</i>	97
Economic Aspect of Hybrid Renewable Energy System for Base Transceiver Station <i>Arwindra Rizqiawan, Erna Garnia, and Pekik Argo Dahono</i>	102
Smart Cocoa Nursery Monitoring System Using IOT for Automatic Drip Irrigation <i>Muhammad Faiz Mohamad Jaafar, Hanim Hussin, Rafidah Rosman, Tee Yei Kheng, Mohamad Ja'afar Hussin</i>	108
Comparative Performance Analysis of Urban and Rural Area using Wi-Fi Direct and DSRC Standard in VANET <i>Nurain Izzati Shuhaimi, Ezmin Abdullah, and Mohammad Anis Adzizee Madzlee</i>	114
Low Split Cloud RAN Opportunities and Challenges <i>Baud Haryo Prananto, Iskandar, and Adit Kurniawan</i>	119
User Acceptance of Predictive Analytics for Student Academic Performance Monitoring: Insights from a Higher Education Institution in the Philippines <i>Mayreen V. Amazona and Alexander A. Hernandez</i>	124
Development of Piezoelectric Energy Harvesting via Vehicle Movements <i>N. Burham, M. N. A. Malek, A. A. Aziz, N. I. Shuhaimi, and A. M. Markom</i>	128
Web-Based Application Design On HAPS For Rural and Disaster Affected Areas <i>Ahmad Fauzi Iskandar, Iskandar, Tutun Juhana, and Hendrawan</i>	132
CMOS LNA Linearization Employing Multiple Gated Transistors <i>Zainorshafiq S.M Salim, Maizan Muhamad, Hanim Hussin, and Norhawati Ahmad</i>	137
Design of 1x2 Circular Ring Microstrip Antennafor Position Detection Application <i>Antrisha Daneraici Setiawan, Ulfah Khaerani Hendariyunisha, Atik Charisma, Sofyan Basuki, Asep Effendi R, and Didin Saepudin</i>	141
Analysis Quality of Service (QoS) on 4G Telkomsel Networks In Soreang <i>Atik Charisma, Antrisha Daneraici Setiawan, Griffani Megiyanto Rahmatullah, and M. Reza Hidayat</i>	145
Design of Ultra-wideband Slotted Microstrip Antenna for WRAN Application <i>Antrisha Daneraici Setiawan, Buyung Astra Angga, Handoko Rusiana Iskandar, Ketut Abimanyu Munastha, Ivany Sarief, and Hardy Purnama Nurba</i>	149
Conversational Recommender System Chatbot Based on Functional Requirement <i>David Theosaksomo, Dwi H. Widiantoro</i>	154

Performance of Tone Modulation Waveform Over Low Latitude Ionospheric Channel <i>Varuliantor Dear, Iskandar, and Adit Kurniawan</i>	160
Verifiability Metric Notion in e-Voting System <i>Teguh Nurhadi Suharsono, Kuspriyanto and Budi Rahardjo</i>	164
Performance of 5G Services Deployed via HAPS System <i>Abdallah A. Abu-Arabia, Iskandar and Rifqy Hakimi</i>	168
Implementation of Harmony in Gradation Concept to Improve Shannon's Information Entropy Formula <i>Sigit Haryadi</i>	173
A Proposed Measurement Method of Internet Services Equity and the Economy Impact <i>Westi Riani and Sigit Haryadi</i>	178
Resource Allocation Analysis with Genetic Algorithm in LTE MIMO-OFDMA Cellular System <i>A. R. Utami and Iskandar</i>	182
NOMA Signal Transmission over Millimeter-wave Frequency for Backbone Network in HAPS with MIMO Antenna <i>Mirrah Aliya Azzahra, Iskandar</i>	186
Blockchain Based School Operational Funding Recording System Design <i>Anisa Fatakh Sabila and Budi Rahardjo</i>	190
Proposed Design and Modeling of Smart Energy Dashboard System by Implementing IoT (Internet of Things) Based on Mobile Devices <i>Syaiful Ahdan, Erliyan Redy Susanto, Nana Rachmana Syambas</i>	194
Design of Power Amplifier and Filter Circuits on Voice Radio Communication for Very High Frequency Spectrum <i>Iskandar, Ian Josef Matheus Edward, Tutun Juhana, Ghufuran Musta'an</i>	200
Prototype of Telemetry, Tracking, and Command module for Tel-USat with BCH code <i>Fachrul Reiza Medina, Heroe Wijanto, Edwar, Bramandika Holy Bagas Pangestu, and Camila Putri Rahmadani</i>	204
Prototype of Micro Reaction Wheel for Cubesat <i>F. H. Manggala, R. P. Ramadhan, H. Wijanto, H. Mayditia, Edwar, H. Vidyaningtyas</i>	209
Catalog Model for Experts on Procurement Projects to Avoid Using Experts Fictitiously in Electronic Procurement Systems <i>Pitara S.W, Bakhtiar, Hendra Garnida, Nenny Hendajany, R. Didin Kusdian, and Suhandi</i>	214
An Investigation of Aircraft Tracking through Space-based ADS-B Receiver <i>T. V. Caya, M. Hafizh, S. O. Benyamin, Edwar, Y. D. Putra, A. K. Widiawan</i>	218
Characterization of On Board Data Handling (OBDH) Subsystem <i>D. Arseno, Edwar, A. R. Harfian, and J. N. Salsabila</i>	223
Smart City Evaluation Model in Bandung, West Java, Indonesia <i>Aisyah Nuraeni, Hendra Sandhi Firmansyah, Ganjar Setya Pribadi, Ahmad Munandar, Leni Herdiani and Nurwathi</i>	228
Implementation Fixed Order Interval Method for Developing Inventory Control System Application <i>Hanhan Hanafiah Solihin, Hendrawan, Wisnu Wijaya, Sofiani Nalwin, Ade Geovania Azwar, Ahmad Munandar</i>	235
Build the Technopreneurship Learning and Entrepreneurial Ecosystem to Create the Entrepreneurial Spirit at Universitas Sangga Buana <i>Asep Effendi R, Fauzan Aziz, Didin Saepudin, Nenny Hendajany, Hayun Setiawan, and Fikri Al-harits Altin</i>	240
Prototype of CanSat with Auto-gyro Payload for Small Satellite Education <i>Rizki Pratama Ramadhan, Aditya Rifky Ramadhan, Shindy Atila Putri, Merlyn Inova Christie Latukolan, Edwar, and Kusmadi</i>	243

Design of Food Security System Monitoring and Risk Mitigation of Rice Distribution In Indonesia Bureau of Logistics <i>Ridho Abdhillah Permana, Ari Yanuar Ridwan, Femi Yulianti, Putu Giri Artha Kusuma</i>	249
Designing Procurement Process Monitoring Dashboard for Supporting Food Security Supply Chain Risk Management System in Indonesian Bureau of Logistics <i>Detha Aulia Alfazah, Ari Yanuar Ridwan, Femi Yulianti and Putu Giri Artha Kusuma</i>	255
Sleeping Cell Analysis in LTE Network with Self-Healing Approach <i>Muhammad Firdaus, Sigit Haryadi, Weryan Shalannanda</i>	261
On the Performance of Router and Switch VNF in a Virtual Internet Lab <i>Angga Friyanto, Eueung Mulyana and Nana Rachmana</i>	267
Asterisk and Radio Over IP Integration at Voice Communication System Air Traffic Control <i>Hendrawan and Bagus Aditya</i>	271
Wireless Telemetry for Real-time Monitoring of Photovoltaic Application System using Monopole Antenna 3DRobotics Radio 915 MHz <i>Handoko Rusiana Iskandar, Sofyan Basuki, M. Reza Hidayat, Antrisha Daneraici Setiawan, Dodi Rukanda and Salita Ulitia Prini</i>	277
Integrating Collocation as TF-IDF Enhancement to Improve Classification Accuracy <i>Gleen A. Dalaorao, Ariel M. Sison and Ruji P. Medina</i>	282
Development of Dual Band Power Divider Using Meander Line Technique for Local Oscillator System <i>Arief Budi Santiko and Achmad Munir</i>	286
Verification Design of Up-Down Frequency Converter Based on Double-Balanced Mixer and Its Performance Characterization <i>Barokatun Hasanah, Deon Arinaldo, Sepanya Pasaribu, Endon Bharata, Mohammad Ridwan Effendi, Arief Budi Santiko, Achmad Munir</i>	290
Multilevel Content Store Performance Analysis on Named Data Network <i>Nana Rachmana S. and Muhammad Putra Pamungkas</i>	294
Author Index	ix

Economic Aspect of Hybrid Renewable Energy System for Base Transceiver Station

Arwindra Rizqiawan
School of Electrical Engineering
and Informatics
Insitut Teknologi Bandung
Bandung, Indonesia
windra@stei.itb.ac.id

Erna Garnia
Faculty of Economics
Universitas Sangga Buana
Jl. PHH Mustofa (Suci) No. 68
Bandung, Indonesia
erna.garnia@usbypkp.ac.id

Pekik Argo Dahono
School of Electrical Engineering
and Informatics
Insitut Teknologi Bandung
Bandung, Indonesia
pekik@konversi.ee.itb.ac.id

Abstract—Economic aspect of hybrid renewable energy system for Base Transceiver Station (BTS) in Indonesia is analyzed in this paper. This analysis is very useful to examine the feasibility of the hybrid renewable system, compare to existing power supply of utility or diesel generator. Firstly, the design for hybrid renewable energy system for on-grid and off-grid BTS is proposed, to be the basis for economic analysis. Economic analysis is conducted based on Levelized Cost of Energy (LCOE) and Life Cycle Cost (LCC). It can be shown that the resulted LCOE is still higher than utility charge, but much lower than diesel generator operation. Although hybrid renewable energy system has higher initial cost, but in the longtime span it has lower future cost.

Keywords—renewable energy, base transceiver station, economic, LCOE, LCC

I. INTRODUCTION

Indonesia as an archipelagic country located in equator has abundant source of renewable energy. Among many renewable energy sources, solar, wind, and biofuel are the most potential energy sources to be developed in Indonesia. Those renewable energy sources potentially to be utilized as alternative energy to reduce fossil-based energy source consumption[1].

The geographical nature of Indonesia also possess challenge that in many islands, the utility company must supply the electricity through small grid system based on diesel genset, not to mention many of the remote islands have not been reached by the electricity from the utility. Diesel generator utilization has consequences of higher electricity cost, while also suffers environmental impact from producing CO₂[2]. Renewable energy sources are very applicable to solve such situation.

Application of renewable energy sources to generate electricity for residential customer has been in progress for last several years, especially in the rural and remote areas of Indonesia. Apart from electricity, another basic needs for people nowadays is communication access. The telecommunication provider must construct base transceiver station (BTS) to expand the range of coverage to reach all people[3][4]. For rural and remote areas in Indonesia, this situation is more difficult because the electricity for powering the BTS is not always available from the utility. The current solution is by installing diesel genset for powering the BTS[5]. This solution has consequence that the telecommunication provider must pay higher electricity cost[6]. Higher energy cost will affect the total operation cost for providing telecommunication access for rural or remote areas, which eventually will slow down the expansion of range of coverage.

This paper proposes the application of hybrid renewable system for powering the BTS. Firstly, the existing power supply configuration of BTS is analysed. Then, basic design of the integration of the existing BTS system and the renewable energy source is shown. An economic assessment based on cumulative cost is conducted to evaluate the feasibility of the proposed system.

II. POWER SUPPLY TOPOLOGY OF BASE TRANSCEIVER STATION

In Indonesia, typically the power supply for BTS can be classified into two types, the on-grid BTS and off-grid BTS, depends on the availability of the supply from the utility.

A. On-Grid Base Transceiver Station

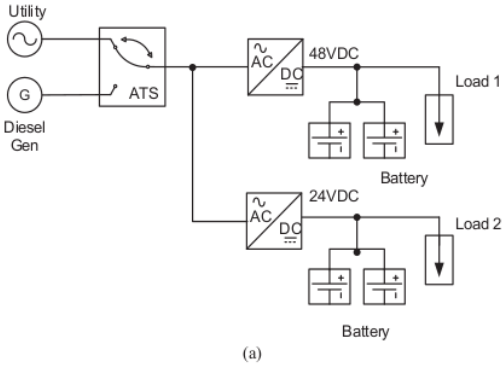
On-grid BTS has utility supply for powering the telecommunication equipment. However, the availability of the utility supply is not fully available to supply all the time in the rural or remote areas in Indonesia. To overcome this situation, it is common practice for telecommunication provider to install its own diesel generator as backup power. Automatic Transfer Switch (ATS) is used to change over between utility supply and the diesel generator.

The existing power supply configuration for on-grid BTS is shown in Fig. 1. Two main DC buses are used, 48VDC bus and 24VDC bus. Each bus has its own rectifier from the common ac bus provided either by utility or diesel generator. The batteries are also available for emergency backup, each bus has its own battery bank. Fig. 1(a) is typically is the most commonly found power topology of BTS, but some other topologies are also available which are 48VDC only bus (Fig. 1(b)), and 24 VDC only bus (Fig. 1(c)).

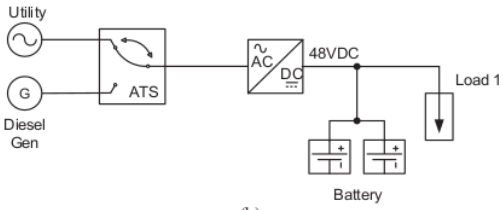
The authors have conducted survey and site visit to 8 sample of locations of on-grid BTS in remote areas in Indonesia. The typical existing power supply capacity are shown in Table 1. Existing BTS uses 20kVA power source for powering the telecommunication loads and charging the battery. Autonomy time provided by battery typically is very long, at least 9 hours of autonomy mode during utility and diesel generator are not available to supply.

B. Off-Grid Base Transceiver Station

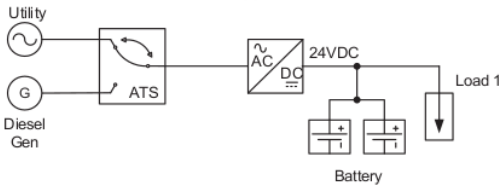
Off-grid BTS does not have utility supply for powering the telecommunication equipment. Commonly, two redundant diesel generators are used to act as supply and backup interchangeably, connected by ATS to transfer the power. Fig. 2 shows typical power supply topology for off-grid BTS under study. Single DC bus of 48VDC is used for powering the equipment. The AC bus receives power from the diesel generator to supply the DC rectifier and AC loads.



(a)



(b)



(c)

Fig. 1. Typical power supply topology of on-grid base transceiver station. (a) 48VDC and 24 VDC dual bus (b) 48VDC only bus (c) 24VDC only bus

Table 1. Typical existing power supply capacity of on-grid BTS in Indonesia

	Utility (kVA)	Diesel Gen (kVa)	Battery autonomy (hours)	Load (kW)
BTS A	20	20	12	6.5
BTS B	20	20	12	9
BTS C	20	20	24	4
BTS D	20	20	25	1.5
BTS E	20	20	17.5	5
BTS F	20	20	9	6
BTS G	20	20	12	7
BTS H	20	20	10	6

The authors also have conducted survey and site visit to 3 sample of locations of off-grid BTS in remote areas in Indonesia. The typical existing power supply capacity are shown in Table 2. Off-grid BTS has bigger load due to in the remote locations the non-equipment loads are dominant, for example the living support for the stand-by officer. Existing BTS uses larger diesel generators for powering the telecommunication loads and charging the battery. Autonomy

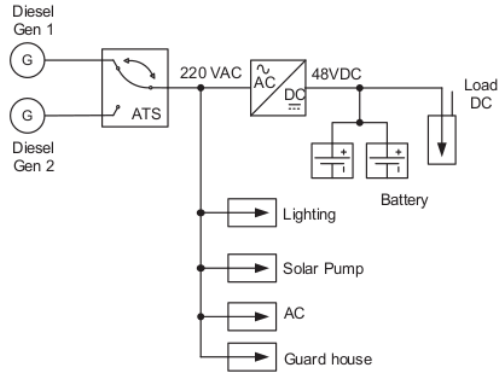


Fig. 2. Typical power supply topology of off-grid base transceiver station

Table 2. Typical existing power supply capacity of off-grid BTS in Indonesia

	Diesel Gen 1 (kVA)	Diesel Gen 2 (kVa)	Battery autonomy (hours)	Load (kW)
BTS I	35	35	4	11
BTS J	50	50	4	16
BTS K	30	30	4	11

time provided by battery typically is very small, only 4 hours of autonomy mode during both diesel generators are not available to supply.

III. HYBRID RENEWABLE ENERGY SYSTEM FOR BASE TRANSCEIVER STATION

Integrating renewable energy source to the existing topology shown in Fig. 1 and 2 will reduce the fuel consumption of diesel generator. Solar energy is the potential source for rural and remote locations in Indonesia. However, space availability is the main factor on how much energy from solar can be harvested in BTS.

Table 3 shows the total space and the space available for implementing solar power in the vicinity of rural and remote BTS. Most of BTS under study has enough space to be implemented with solar power as hybrid renewable energy system. Based on the space availability and the BTS loading, the estimated PV capacity is shown in Table 5.

To implement hybrid renewable energy system by using solar power in BTS, it is desired to do minimal modification from the existing power supply topology. Fig. 3 and 4 show the proposed hybrid renewable energy system for BTS based on the existing topology as shown in Fig. 1 and 2.

In general, the proposed hybrid renewable energy system for BTS comprises of solar charge controller, a DC-DC converter which has maximum power point tracking feature. Solar charge controller converts the output voltage of photovoltaic (PV) panel to the DC bus voltage, either 48 VDC (as in Fig. 3(a) and (b)) or 24 VDC (as in Fig. 3(c)). Solar charge controller has function to send the generated power to the load and charge the battery. Solar charge controller is also able to send command for operating either utility supply or diesel generator in the case of on-grid BTS, or diesel generators in

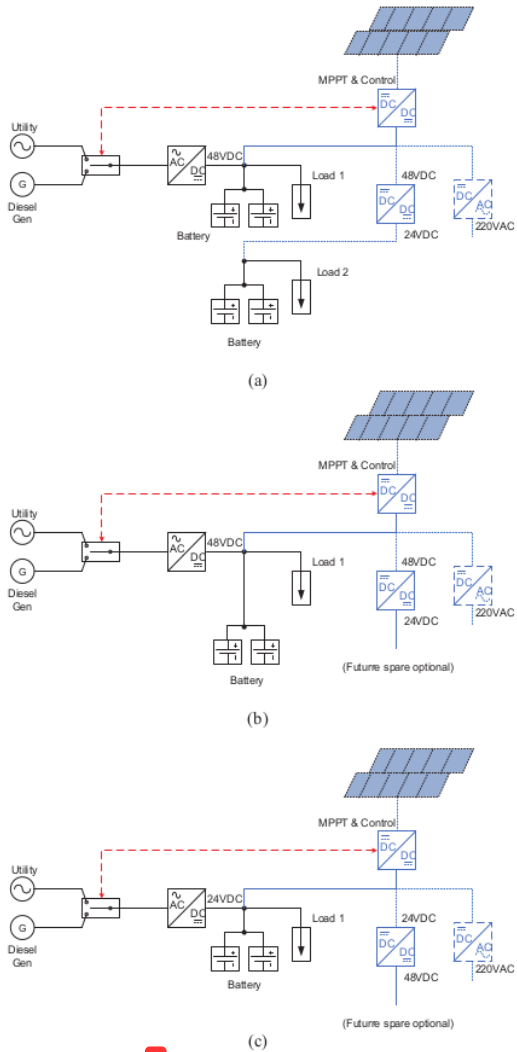


Fig. 3. Proposed hybrid renewable energy system for on-grid base transceiver station (a) 48VDC and 24 VDC dual bus (b) 48VDC only bus (c) 24VDC only bus

the case of off-grid BTS. The level of priority of the power supply is shown in Table 4 for on-grid and off-grid BTS. In the case of solar power is unavailable, utility power is prioritized instead of battery in the case of on-grid BTS. Since utility power is unavailable in the off-grid BTS, the priority level for battery is increased to supply the load in the case of solar power unavailable. In both on-grid and off-grid BTS, diesel generator has less priority due to high energy cost.

Dc-dc converter then is used to convert 48 VDC in the main bus to 24 VDC bus, therefore the existing 24 VDC rectifier is no longer required (as in Fig. 3(a)). An inverter is also required to convert 48 VDC to 220 VAC to supply local AC loads, if available. Similar concept is applied to implement hybrid renewable energy system to the off-grid BTS, as shown in Fig. 4. While the level of priority is also shown in Table 4.

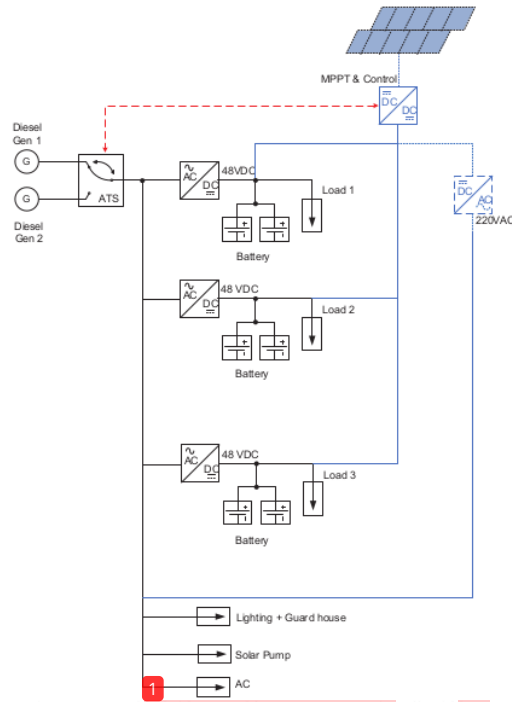


Fig. 4. Proposed hybrid renewable energy system for off-grid base transceiver station

Table 3. the total space and the space available for implementing solar power

	Total space (m2)	Available space (m2)	Available space (%)
BTS A	300	160	53
BTS B	300	150	50
BTS C	300	100	33
BTS D	300	112	37
BTS E	300	150	50
BTS F	300	150	50
BTS G	300	100	33
BTS H	300	150	50
BTS I	2572	974	38
BTS J	3060	1472	48
BTS K	2400	780	32

On-grid BTS is designed to keep the utility and diesel generator as the backup source, while install sufficient capacity of PV to be the main source. In this analysis, it is assumed that the equivalent sun hour (ESH) for the locations in Indonesia is 4 hours, to take into account the performance ratio of a PV plant. The availability of the utility in the remote areas in Indonesia is assumed only 12 hours per day in average. Therefore, the rest of the time must be supplied from the battery, while diesel generator is less prioritized due to the expensive fuel cost.

Table 4. Priority level of power supply

	On-grid BTS	Off-grid BTS
Level 1	Solar	Solar
Level 2	Utility	Battery
Level 3	Battery	Diesel Generator
Level 4	Diesel Generator	-

Table 5. Proposed design of hybrid renewable energy system for BTS

	Existing design	Proposal design	PV Capacity (kWp)	Battery autonomy (hours)
BTS A	Fig. 1a	Fig. 3a	21	9
BTS B	Fig. 1a	Fig. 3a	31	9
BTS C	Fig. 1a	Fig. 3a	14	9
BTS D	Fig. 1b	Fig. 3b	6	9
BTS E	Fig. 1c	Fig. 3c	17	9
BTS F	Fig. 1b	Fig. 3b	23	9
BTS G	Fig. 1a	Fig. 3a	24	9
BTS H	Fig. 1a	Fig. 3a	24	9
BTS I	Fig. 2	Fig. 4	60	20
BTS J	Fig. 2	Fig. 4	90	20
BTS K	Fig. 2	Fig. 4	60	20

Similar concept is applied for off-grid BTS, however since no utility available, the battery must be longer to cover the loads. Diesel generator is also less prioritized. Table Y shows the design proposal for each BTS under study. Based on the space availability and the BTS loading, the estimated PV capacity is also shown in Table 5.

IV. ECONOMIC ASPECT OF HYBRID RENEWABLE ENERGY SYSTEM FOR BASE TRANSCIEVER STATION

The ownership of the hybrid renewable energy system of BTS is owned by the telecommunication company itself, therefore no definitive energy price is set by the buyer. To adapt with this situation, two parameters of economic feasibility are used in this study, namely Levelized Cost of Energy (LCOE) and accumulation cost to predict the payback time.

A. Levelized Cost of Energy

Levelized Cost of Energy (LCOE) is a measure of lifetime cost of an energy plant divided by its energy production during the life span [7][8]. The LCOE calculates the present value of the total investment and operation cost over an assumed lifetime span. This approach allows the comparison of different technology or energy sources, even for unequal lifetime span, capital cost, risk, return. Simplified expression for calculating LCOE is shown in Eq. (1). Where I_t is the investment in year t , M is operation and maintenance cost in year t , F_t is the fuel expense in year t , E_t is electricity generation in year t , r is the discount rate, and n is the lifetime span of the project.

$$LCOE = \frac{\sum_{t=1}^n \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^n \frac{E_t}{(1+r)^t}} \quad (1)$$

LCOE analysis was run in all the BTS under study based on the design shown in Table Y. Based on the current price, the assumptions for cost analysis for this study is shown in Table 6.

Fig. 5 shows the LCOE for on-grid BTS in comparison with the utility charge. The expected cost for hybrid renewable energy for BTS is in the range of 0.485 – 0.5 USD/kWh. Much higher than utility charge which cost only 0.1 USD/kWh. From the economic point of view, higher LCOE means the hybrid renewable energy system is not feasible for BTS. However, if we take into account the reliability of the utility supply that is not 100%, hybrid renewable energy system for BTS is an option that can be considered since the estimated LCOE will surely below the LCOE of diesel generator operation.

Fig. 6 shows the LCOE for off-grid BTS in comparison with LCOE of diesel generator operation. The LCOE for off-grid BTS by using hybrid renewable energy system is similar with the LCOE on-grid BTS. However, the expected cost is much lower than the LCOE based on diesel generator operation. In the case of off-grid BTS, the hybrid renewable energy system is potential solution from the economic point of view.

B. Life Cycle Cost

Life Cycle Cost (LCC) analysis is the approach to know the total cost of owning, operating, and maintaining a facility [9]. Different technology applied for a solution has a different combination of initial cost and future cost. This will bring difficulty in making consistent comparison between two or more solutions. LCC is preferred to evaluate different solutions with different initial and future cost. LCC considers the total cost of a solution by accumulating the discounted annual costs over its lifetime span.

Fig. 7 and 8 shows a case of life-cycle cost of hybrid renewable energy system for on-grid and off-grid BTS, respectively. These selected cases are representative since the size is relatively similar for on-grid or off-grid BTS. Since comparison with the utility will not produce competitive situation, in this study comparison with diesel generator operation is analysed under assumption that the reliability from utility supply is not fully available. The hybrid renewable energy system has higher initial cost, but less future cost, compare to the diesel generator operation. This analysis provides insight that in the long run, the hybrid renewable energy system uses less cost than diesel generator supply system. The long-term saving opportunity is the attractive

Table 6. Cost assumptions

	Cost Assumptions	
Fuel Price	1	USD/litre
Interest rate	12	%/year
PV Investment	8000	USD/kWp
Battery Investment	400	USD/kWh
Utility Charge	0.1	USD/kWh

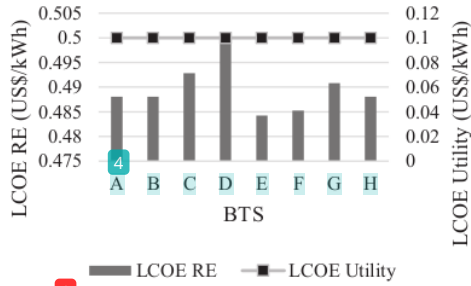


Fig. 5. LCOE of hybrid renewable energy system for on-grid BTS.

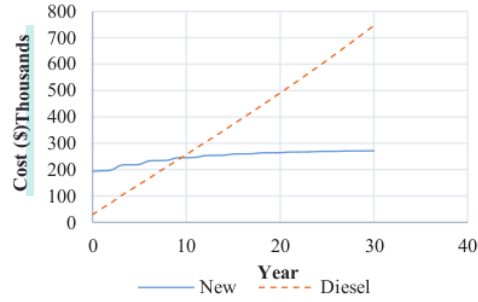


Fig. 7. Cumulative cost of on-grid BTS: Case BTS A

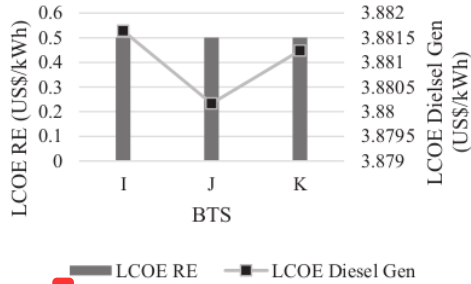


Fig. 6. LCOE of hybrid renewable energy system for off-grid BTS.

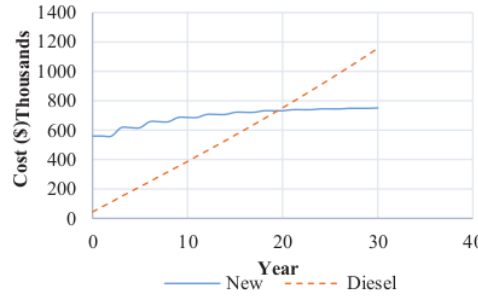


Fig. 8. Cumulative cost of off-grid BTS: Case BTS I

point for the provider, although it must invest to install hybrid renewable energy system in the beginning.

Simple payback time can be deduced based on the intersection between cumulative cost of hybrid renewable energy system and diesel generator operation. Fig. 9 and 10 shows the estimated simple payback time of the BTS under study, both for on-grid and off-grid, respectively. To put into perspective, the capacity of PV for each BTS is also shown as the reference. Hybrid renewable system for on-grid BTS has simple payback time in the range of 6-11 years, while off-grid BTS has 20 years. These results are understandable since the capacity of PV installed in the off-grid BTS is larger than PV in on-grid BTS.

V. CONCLUSIONS

In this paper, economic analysis of hybrid renewable energy system for **B1** Transceiver Station is conducted. LCOE analysis show that hybrid renewable energy system of on-grid BTS has higher cost of energy compare to utility charge, but the risk of using costly diesel generator is exist due **1** the reliability of the utility supply. In contrast, LCOE of hybrid renewable energy system of off-grid BTS is much **1**wer than LCOE of diesel generator operation. In the case of **2**ff-grid BTS, the hybrid renewable energy sy**5**em is potential solution from the economic point of view. Life Cycle Cost analysis is used to obtain the total cost of the proposed hybrid renewable energy solution for BTS. In the lifetime span, hybrid renewable energy system uses less cost than diesel generator supply system.

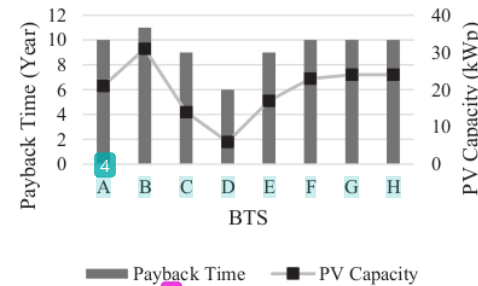


Fig. 9. Payback time for hybrid renewable energy system for on-grid BTS

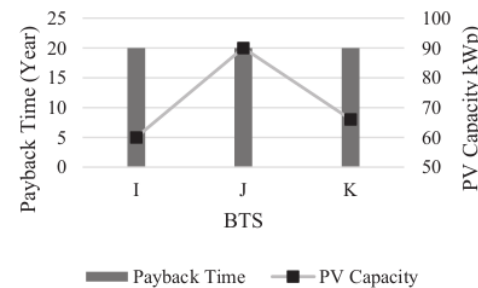


Fig. 10. Payback time for hybrid renewable energy system for off-grid BTS

REFERENCES

- [1] -, "National energy general plan", Republic of Indonesia Presidential Regulation, No. 22, 2017.
- [2] J. Schofield, "Comparing the environmental impacts of diesel generated electricity with hybrid diesel-wind electricity for off grid first nation communities in ontario : incorporating a life cycle approach" (2011). Theses and dissertations. Paper 1664.
- [3] K. R. Milani, B. Adham, M. R. Banaei, and F. M. Kazemi, "Measurement and analysis of base transceiver stations power quality parameters and assessment of its unfavourable effects on iran distribution systems", *CIREC, Open Access Proc. J.*, 2017, Vol. 2017, Iss. 1, pp. 761–765.
- [4] L. M. Correia, D. Zeller, O. Blume, D. Ferling, Y. Jading, I. Gódor, G. Auer, L. Van der Perre, "Challenges and enabling technologies for energy aware mobile radio networks", *IEEE Communications Magazine*, November 2010, pp. 66 – 72.
- [5] P. A. Dahono, M. F. Salam, F. M. Falah, G. Yudha, Y. Marketatmo, and S. Budiwibowo, "Design and operational experience of powering base transceiver station in indonesia by using a hybrid power system", 31st International Telecommunications Energy Conference, INTELEC 2009.
- [6] S. K. Bhondge, D. B. Bhojar, S. Mohad, "Strategy for power consumption management at base transceiver station", 2016 World Conference on Futuristic Trends in Research and Innovation for Social Welfare (WCFTR'16).
- [7] T. Georgitsioti, N. Pearsall, and I. Forbes, "Simplified levelised cost of the domestic photovoltaic energy in th uk: the importance of the feed-in-tariff scheme", *IET Renew. Power Gener.*, 2014, Vol. 8, Iss. 5, pp. 451-458.
- [8] -, "Projected costs of generating electricity," IEA, Paris, France, 2015.
- [9] T. Mearig, and L. Morris, "Life cycle cost analysis handbook", Dept. of Education & Early Development, State of Alaska, 2018.

Plagiarisme_TSSA 13th

ORIGINALITY REPORT

7%

SIMILARITY INDEX

7%

INTERNET SOURCES

7%

PUBLICATIONS

%

STUDENT PAPERS

PRIMARY SOURCES

1

link.springer.com

Internet Source

4%

2

www.ncbi.nlm.nih.gov

Internet Source

1%

3

Oladimeji Ibrahim, Mutiu Shola Bakare, Temitope Ibrahim Amosa, Abdulrahman Okino Otuoze et al. "Development of fuzzy logic-based demand-side energy management system for hybrid energy sources", Energy Conversion and Management: X, 2023

Publication

1%

4

en.m.wikipedia.org

Internet Source

1%

5

www.casindo.info

Internet Source

1%

Exclude quotes On

Exclude matches < 1%

Exclude bibliography On

