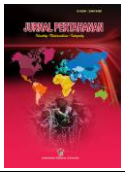

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Optimization of Renewable Energy Sources in the Development of a Military Microgrid at Indonesia Defense University

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Abstract

The availability of electricity is crucial for the smooth operation and administration of any institution, including the Republic of Indonesia Defense University. This study aims to investigate the implementation of the Military Microgrid, an innovative concept developed to increase the development of renewable energy sources for defense agencies. The researchers employed a qualitative approach, conducting interviews and gathering data from various sources, including relevant laws and regulations. Implementing the Military Microgrid system at the Indonesia Defense University presents a practical and sustainable solution to meet the university's electricity demands while promoting environmental sustainability. The initiative aligns with the Indonesian government's renewable energy goals and can serve as a promising solution for other institutions to follow. This concept has facilitated the exploration of environmentally friendly energy sources from nature, such as solar, water, waste, and biomass. The Military Microgrid is an effective solution to meet the demand for electricity in defense agencies while promoting the use of renewable energy sources. The implementation of Law No. 23 of 2019 concerning the Management of National Defense Resources has provided a legal framework for developing and implementing this innovative concept. This study highlights the importance of exploring and utilizing renewable energy sources to meet the growing demand for electricity in institutions especially military and defense institutions.

INTRODUCTION

The Indonesia Defense University's effort to develop a renewable energy-based electrical system is influenced by several factors, including the high cost of electricity

and the need to optimize the use of natural resources for the benefit of national defense (Ministry of Energy and Mineral Resources, 2020). Preliminary data regarding the relative amount of electricity bills issued by the Indonesia Defense University through the Directorate of Facilities and Services Ministry of Defense of the Republic of Indonesia (Ditfasjas or *Direktorat Fasilitas Dan Jasa Kementerian Pertahanan Republik Indonesia*) each hundred of millions of rupiah each month, making the authors try to formulate an alternative solution through the Optimization of NRE (New Renewable Energy) sources in the development of Military Microgrid on the Indonesia Defense University Sentul campus as a defense implementation that supports development energy sources.

The Military Microgrid concept is proposed to address these challenges by utilizing optimized renewable energy sources such as water, solar, waste, biomass, and wind energy to provide reliable and sustainable electricity (Oriti, Anglani, & Julian, 2019). The Indonesia Defense University's location provides ample potential for renewable energy sources. The abundance of water sources, such as rivers, provides a source of hydroelectric power, while the area's ample sunlight is ideal for solar power generation (Nurdiansah, Purnomo, & Kasiwi, 2020). Additionally, the academic community generates a significant amount of food waste, which can be utilized as a source of energy. Biomass energy sources from plants that thrive around the Indonesia Defense University area and the wind energy potential from the mountainous terrain further add to the viability of the Military Microgrid concept.

The implementation of the Military Microgrid system aligns with the Indonesian government's target of achieving a 23% national energy mix from new and renewable energy sources by 2025 (Ministry of Energy and Mineral Resources, 2020). The initiative aims to promote the use of renewable energy sources in all aspects of the university, from laboratory buildings to faculty buildings and cadet dormitories. The use of renewable energy sources such as water, solar, waste, biomass, and wind energy can reduce the university's dependence on non-renewable energy sources, leading to cost savings and a reduced carbon footprint (Saad & Abdullah, 2018).

In this case, theoretical or applicable contributions will be given to review the use of NRE from an optimization (mathematical) perspective, especially the development of NRE sources as a Military Microgrid concept at the Indonesia Defense University Sentul campus. It is hoped that the study of renewable energy sources as a source of electricity can be applied to the construction of Indonesia Defense University undergraduate program buildings, such as laboratory buildings, lecture buildings, and faculty buildings to Cadet Dormitories through a concept called Military microgrid. Implementing the Military Microgrid system at the Indonesia Defense University presents a practical and sustainable solution to meet the university's electricity demands while promoting environmental sustainability. The initiative aligns with the Indonesian government's renewable energy goals and can serve as a promising solution for other institutions to follow (Sugiyono, 2017). This study aims to investigate the implementation of the Military Microgrid, an innovative concept developed to increase the development of renewable energy sources for defense agencies.

METHODS

Research Methods and Design

A descriptive quantitative method is a tool that can be used to analyze primary and secondary data to produce interesting studies that will be presented in the form of databases and interesting infographics that are easy to understand or use (Kock & Hadaya, 2018). This research design is non-experimental. The primary data is obtained from the measurement of the potential of new and renewable energy (NRE) sources combined with the installation of NRE sources, while the secondary data is obtained through agencies or institutions or organizations that have utilized NRE sources.

Energy potential optimization steps for Military Microgrid

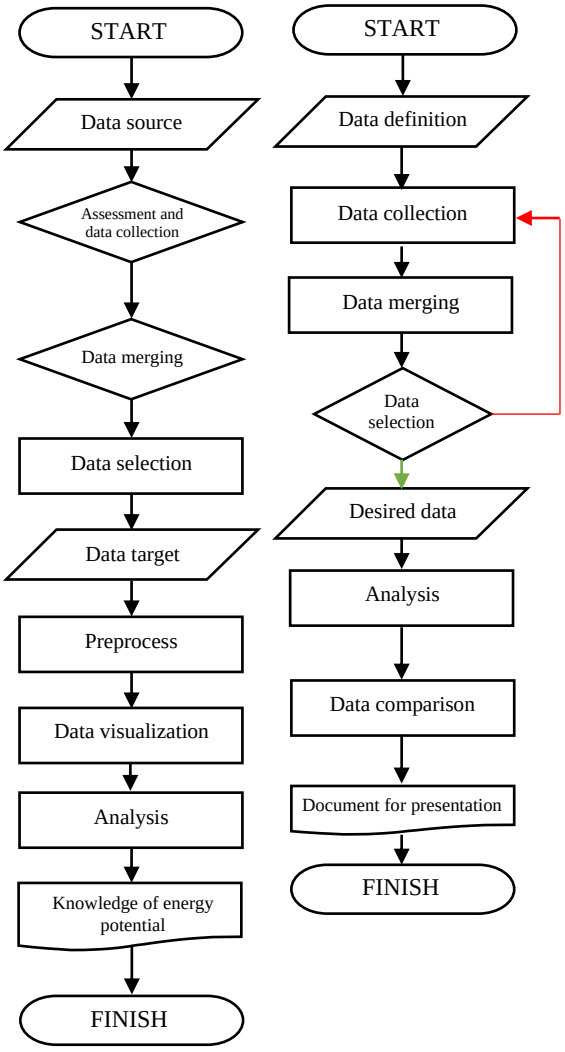

Figure 1. Research Flowchart

Definition of Research Object

The object of this research is the potential of renewable energy, especially solar energy at the Indonesia Defense University, and extended to the calculation of the large percentage of electrical energy produced by renewable energy which can reduce the electricity supply from the National Electricity Company (*Perusahaan Listrik Negara* or

PLN) in the Indonesia Defense University building. So, the population is a collection of energy sources around campus, while the samples are sources of solar energy, waste, or water (micro hydro) to biomass.

Data collection and literature review

Data collection and literature review are two critical components of any research project. The process of data collection should be systematic, unbiased, and reliable to ensure the accuracy and validity of the results (Kadam & Bhalerao, 2018). It involves gathering information from various sources such as surveys, interviews, observations, and exercises of existing datasets. Meanwhile, the literature review is essential for identifying gaps in current knowledge and providing a theoretical framework for the study. It helps to refine research questions, determine the appropriate methodology, and contextualize the findings. Proper data collection methods ensure the results' accuracy and reliability, as Smith (2018) emphasized. In this study, the data collection techniques involved a site review process and expert consultations to evaluate the conditions of the area where the military microgrid concept will be applied. The data collected from different sources were compiled into Microsoft Word or Microsoft Excel.

A systematic literature review can assist in identifying and analyzing previous studies related to the research question or topic. By critically evaluating existing research papers, researchers can determine the strengths and weaknesses of previous studies and identify research gaps that need to be addressed. This process can help refine research questions and determine the appropriate methodology for the study. According to Green & Johnson (2019), a literature review can also help to contextualize the study findings within existing knowledge and theories. In this study, a comprehensive literature review was conducted to identify relevant research papers related to the military microgrid concept and to gain insights into similar studies conducted in the past. The results of the literature review were used to guide the data collection process and provide a theoretical framework for the study.

Data collection and literature review are essential components of any research project. By using appropriate data collection methods and conducting a comprehensive literature review, researchers can ensure the accuracy and validity of their findings. These processes enable researchers to identify gaps in current knowledge, refine research questions, and develop appropriate methodologies. In this study, the data collection techniques and literature review process were crucial in providing a comprehensive understanding of the military microgrid concept and evaluating the conditions of the area where the concept will be applied.

Data merging

Merging data is a new database process, the data collection process will be compiled into a Microsoft Word or Microsoft Excel file for further cleaning and preparation of the database so that the collected data is ready to be processed. Data merging needs to be done carefully because errors in data merging can produce distorted results and even mislead further retrieval.

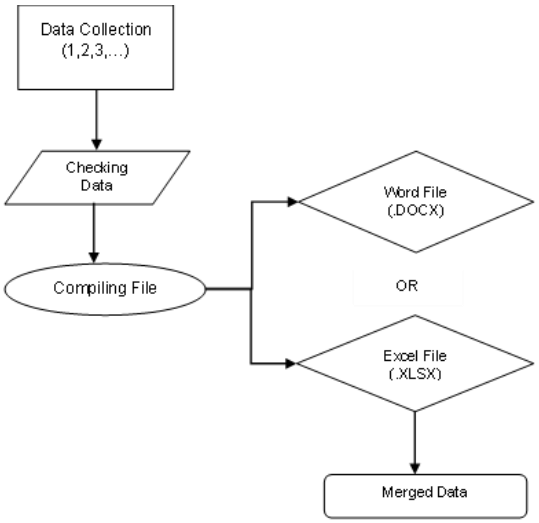

Figure 2. Data Merging Diagram

Data Selection

Data selection is a crucial component of the data analysis process as it involves identifying and choosing relevant data for analysis. The selection process typically involves determining the scope of the analysis, defining the research question, and identifying sources of data that are appropriate for answering the research question (Patton, 2015). Once potential sources of data have been identified, the researcher must then evaluate each source for its relevance, accuracy, and completeness. This may involve reviewing and sorting through large amounts of data to identify key pieces of information that are relevant to the research question. According to Patton (2015), data selection should be guided by a clear understanding of the research question and the desired outcomes of the analysis. By carefully selecting and analyzing relevant data, researchers can ensure that their findings are reliable, valid, and meaningful. For example, a case study of hydro energy potential does not need to include data on local economic or demographic conditions that may be collected during the data collection process.

Data analysis

Data analysis is a systematic process that involves finding and compiling data from interviews, observations, and documents, and presenting conclusions in an easy-to-understand manner (Sugiyono, 2017). However, when combined with literature, this process can lead to a deeper understanding of the phenomenon being studied. Data analysis with literature is a method that involves analyzing data in conjunction with existing literature and theories to identify patterns, trends, and relationships, to gain a more comprehensive understanding of the data and inform future actions (Maqbool, Khan, & Ullah, 2018). By comparing social media data with literature on online communication, for instance, researchers can identify how social media is impacting communication patterns, identify gaps in existing research, and suggest potential research directions. As Boote & Beile (2005) suggest, integrating literature into data analysis provides a rich and nuanced understanding of the phenomenon being studied,

as well as a deeper appreciation of the complexity of the data. Overall, data analysis with literature is an approach that provides a more holistic perspective on data and its implications.

Comparison of data

Comparison of data is a process of comparing data to get more confidence in the truth of the results of the analysis made from research and data that has been collected.

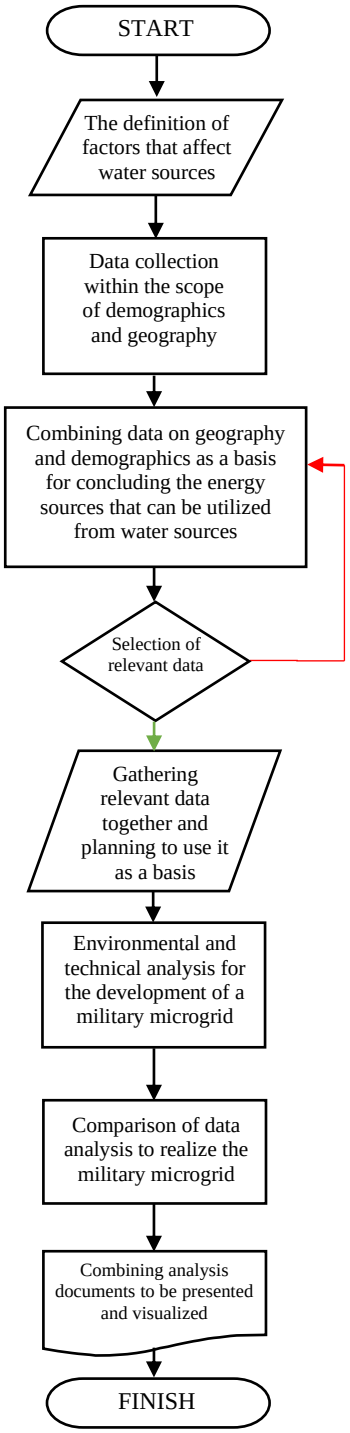

Figure 3. Example of Making a Military Microgrid from the water source

According to Faisal and Atmaja (2019), water is an essential element in the environment that is influenced by various factors. If the quality of water deteriorates, it can have negative impacts on human health, safety, and the lives of other living creatures. This can also reduce the benefits, productivity, carrying capacity, and resource sustainability of water resources, leading to the depletion of natural resources. Water sources are influenced by the geographic location of an area, such as the type of soil and rocks beneath the surface. Mountainous areas tend to have abundant water sources due to high rainfall, while the topography of an area also affects water sources. Areas with steep slopes and many water channels will have large rivers.

In addition, weather factors such as rainfall, temperature, and climate also affect the availability of water in an area. Areas that often experience drought will have fewer water sources and may depend on groundwater sources. On the other hand, tropical areas with high rainfall and stable temperatures tend to have abundant water sources, while desert areas with low rainfall and extreme temperatures have very limited water sources. To examine the geographic aspects, a survey is conducted to understand the demographics in the specified location, and data is collected from the survey results and Google Earth. The collected data is then cleaned by evaluating the sources and methods of data collection. Relevant data is analyzed first by experts to form the basis for developing an alternative military microgrid. The results of the experts' study are then compiled in documents for comparison to optimize the development of the military microgrid.

RESULTS AND DISCUSSION

From the perspective of defense mathematics, the military microgrid as a technological innovation in the energy sector is certainly a very good and interesting innovation. In particular, from the point of view of optimizing the energy used in day-to-day military operations and administration. The military microgrid is an effort to develop national defense forces through the management of Indonesia's national resources to realize a formidable national defense. This is by what is stated in Law No. 23 of 2019 concerning the Management of National Resources for National Defense. To process and manage it all, it is necessary to have qualified human resources. These human resources can be grouped into three major groups, namely academics (Indonesia Defense University), the industrial world, and the community with their respective roles. Academics (Indonesia Defense University) are tasked with issuing ideas on how to process and manage existing energy sources so that they can be useful by utilizing existing national facilities and infrastructure. As for the industrial world, as a supporter of the realization of the technical idea of processing and managing energy sources through the existence of owned capital (capital owner). Furthermore, the community plays a role as custodians, conservationists, users, and developers so that the output of the process can still exist so that the energy security obtained to support food security and water security can be realized and national defense can occur in real terms. Therefore, the utilization of Indonesia's existing resources with the support of national

facilities and infrastructure can be carried out properly so that energy security is achieved where it will be able to realize good national defense.

Military Microgrid for National Defense and Analysis of NRE Potential

From the explanation above, it appears that water security, food security, and energy security which will be increasingly threatened with scarcity in the future can be determining factors for national security. Because water, food, and energy are getting scarcer, each country will be increasingly competing and sacrificing anything to get it. That way, the competition is getting tougher, so more will need to be sacrificed to win. While on the other hand, other things such as politics, economy, society, and geography will also adjust to this scarcity trend. All of these things will be deployed to achieve food, water, and energy goals. For this reason, the Military Microgrid concept that will encourage the development of energy security is a solution that is urgently needed at this time. On the other hand, the implementation of the development of the Military Microgrid will not run well without an analysis of the potential of NRE in the surrounding environment. By first analyzing the potential of NRE in the surrounding environment, the type, size, and shape of the Military Microgrid installations can be estimated in advance, and that makes the construction of the Military Microgrid more scalable and its benefits guaranteed.

Primary Energy Sources and Energy Storage Media

Solar Power Plants (PLTS)

Solar Power Plants (PLTS) are power generation equipment that converts solar power into electricity. PLTS is often also called Solar Cell, Solar Photovoltaic, or Solar Energy. PLTS utilizes sunlight to generate electricity. DC (Direct Current) can be converted into AC (Alternating Current) electricity if needed. Therefore, even though it is cloudy, as long as there is light, PLTS can generate electricity (Lg, n.d.). Solar panels with angles that can be adjusted to the sun's position, using photovoltaic hybrid panels with thermals to get the effect of panel temperature on generation efficiency as well as generating hybrid electricity from hot water. The generator dashboard is used to obtain data and generation characteristics from the sun (solar) throughout the year (Lg, n.d.).

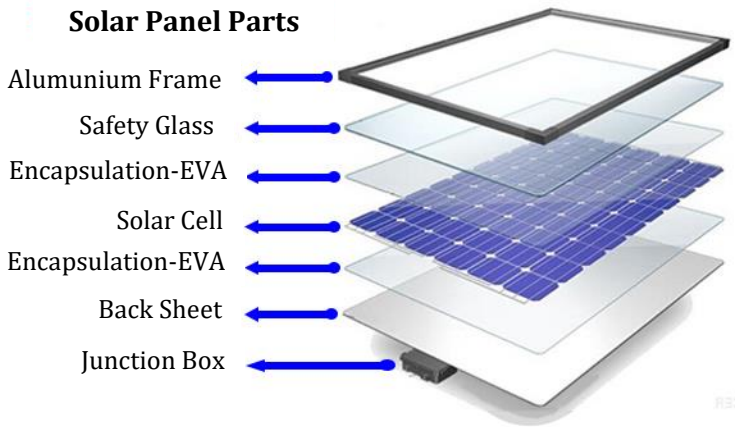

Figure 4. Parts of a Solar Panel

Waste Energy (PLTSa/Pembangkit Listrik Tenaga Sampah or Garbage power plant*)*

Waste is material that has no value or is not valuable for ordinary or primary purposes in the manufacture or use of damaged or defective goods in manufacturing or excess or rejected materials or waste (Nurdiansah et al., 2020). A Waste Power Plant or PLTSa is a power plant that uses waste as its energy source (Satrio, n.d.).

Figure 5. Patriot 77 Prototype

The military microgrid PLTSa uses biomass as the main ingredient to generate electricity. In the military microgrid, Biomass is obtained from inorganic waste (in the form of paper, wood, and others besides glass, metal, and plastic) which is processed in such a way using the innovation "Patriot 77", so that the biomass used is not bought but created itself. Each “Patriot 77” innovation operates using 1 kg of waste and produces up to ± 0.698 kg of biomass and also produces ± 2.142 liters of pesticides.

Water Energy (PSH–Pump Storage Hydroelectricity)

PSH or Pump Storage Hydroelectricity is a method of storing and producing electricity by moving water between two reservoirs of different heights. At the Indonesian Defense University, PSH or Pump Storage Hydroelectricity utilizes complex hill contours with a height of up to 40 meters. One of the biggest challenges in utilizing several renewable energy sources is the fluctuation in energy supply due to the natural characteristics of various energy sources such as solar photovoltaic and wind power. Because the electricity generated from solar photovoltaic and wind power is highly dependent on the amount of sunlight intensity and wind speed, these two technologies produce electricity on an intermittent basis, making it difficult to serve as a base load in the national electricity supply. Other types of renewable energy such as hydropower will also experience difficulties because the dry season is predicted to be increasingly unpredictable due to the global climate crisis (Li et al., 2010) drought severity, and production yield. In this military microgrid, water energy operations will be integrated with other power plants so that later a complementary energy security system will be

formed from the three power plants. This means that when a hydroelectric power plant is temporarily unable to operate due to climate problems, another power plant can first support the supply of electricity. At the same time happens when other power plants experience the same thing.

Military Microgrid to Strengthen National Defense

Figure 6. The general condition of Indonesia's energy security (Strategic Plan of Ministry of Energy And Mineral Resources for 2020-2024*)*

The military microgrid is a technological innovation in the energy sector, which is particularly important for the optimization of energy used in day-to-day military operations and administration (Ahmadi & Moghaddam, 2019). Its development aims to enhance national defense forces by managing Indonesia's national resources to create a formidable national defense, as stated in Law No. 23 of 2019 concerning the Management of National Resources for National Defense. Renewable energy sources are one of the keys in the field of national defense. The Indonesian Defense University is a campus under the auspices of the Indonesian Ministry of Defense. Optimization of renewable energy sources on the Indonesia Defense University campus will be very useful in the development of the national defense sector. One of the concepts that can be implemented is the Military Microgrid. The military microgrid concept is implemented by applying smart buildings.

From the perspective of defense mathematics, the military microgrid as a technological innovation in the energy sector is certainly a very good and interesting innovation. In particular, from the point of view of optimizing the energy used in daily military operations and administration, a military microgrid that is integrated with various energy sources can be an efficient and effective solution. In this case, the author makes a brief study in tabular form which describes how a mathematical model can later be formulated to show the efficiency of a military microgrid.

Table 1. Comparative Table of Military Microgrid Use with Conventional

No.	Military Microgrid	Conventional
1	Cheaper energy access costs	Energy access costs are more expensive
2	Manufacturing Costs and land are more expensive	Manufacturing Costs and land are more expensive

3	Operating Costs tend to be expensive	Operating Costs Tend to be Cheaper
4	Maintenance Costs Tend to be More Expensive due to innovation	Maintenance Costs Tend to be cheaper as they are well known

Looking at Table 1, it can be understood that the military microgrid in its development and development process must consider the above factors to later form a mathematical model that can demonstrate the efficiency of this military microgrid program. If later it is proven mathematically that this military microgrid is profitable, then the development can proceed to the manufacturing stage.

CONCLUSIONS, RECOMMENDATIONS, AND LIMITATIONS

The Indonesia Defense University has a lot of potential sources of renewable energy, such as:

1. the weather tends to be hot all year round;
2. extensive land in the form of rooftops in each campus building;
3. garbage that overflows from the daily needs of the Indonesia Defense University academic community; and
4. waste processing system that is less than optimal.

Garbage has the potential to become a Waste Power Plant (PLTS). It is hoped that this can support electricity in the concept of smart buildings on the Indonesia Defense University in Sentul campus. In addition to the above potential, the Indonesia Defense University also has the potential for micro-hydro installation, due to the many rivers and areas of fast-flowing springs. So, it can be concluded that the form of realization of the military microgrid at the Indonesia Defense University is a smart building campus in the form of:

1. integrated PLTS that produces electricity output;
2. solar panels that produce electricity output;
3. micro hydro installation which can be used as supporting energy; and
4. smart system building integrated with UI.

The Military Microgrid concept can be implemented through the integration of various renewable energy sources. To achieve this, it is recommended that the campus authorities prioritize the development of an optimal waste processing system and consider the installation of a micro-hydro plant. Additionally, there should be continuous efforts to increase the efficiency of the PLTS and solar panel systems. Moreover, it is recommended that the campus authorities collaborate with experts in the field of renewable energy to provide training and development programs for the academic community. These programs will not only increase the knowledge and skills of the academic community but will also facilitate the development of renewable energy systems on campus.

One of the limitations of implementing the military microgrid concept at the Indonesia Defense University is the initial cost of installation. The integration of various renewable energy sources requires a significant investment of time and resources, which may be a challenge for the campus authorities. Additionally, the maintenance cost

of renewable energy systems may also be high. Therefore, it is recommended that the campus authorities conduct a cost-benefit analysis to ensure that the long-term benefits of implementing the military microgrid concept outweigh the initial and maintenance costs. Another limitation is the availability of technical expertise. The installation, maintenance, and management of renewable energy systems require specific technical skills and knowledge. Therefore, it is recommended that the campus authorities collaborate with experts in the field of renewable energy to ensure the efficient and effective operation of the military microgrid concept. Finally, it should be noted that the military microgrid concept at the Indonesia Defense University should not compromise the security and safety of the campus. Therefore, the integration of renewable energy sources should be carried out with proper risk assessments and security measures in place.

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