Efficiency analysis on the inverter using the energy-saving lamp

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Abstract. Electric energy savings are influenced by magnitude of reactive power used by electric customers, one of the tools that can minimize reactive power is the inverter, which is an electronic equipment, that can change the direct current of electricity to alternating current. The method used is by measuring along with analysis of calculation each time the inverter is given the burden of energy-saving lamps with varying power to determine the change in the electrical quantities to be analyzed. Inverter efficiency in doing the convert direct current to alternating current during low load (5W) amounted to 94.66%, and the highest load current (203W) amounted to 90.55%.

Keywords: Inverter, Energy Saving, Efficiency

1. Introduction
Indonesia is the largest consumption energy in Southeast Asia, thus the strategy of saving energy, costs and reducing emissions is important issue in this country. The subsidies have been taken off cause the electricity tariffs increased [1], especially for household customers. Therefore, the reactive power resulting in the loss of active power must be reduced so that electricity will be used by customers to be better, Electric energy savings are influenced by the magnitude of reactive power used by electric customers, one of the tools that can minimize reactive power is the inverter [2], which is an electronic equipment that can change the direct current of electricity from devices such as batteries, accumulators or solar cells into electric current alternating current. This tool can also work to back up electricity at home within a certain time (temporarily) when there is no power supply.

To cope with power outages, especially in households, it is necessary to have emergency equipment capable of working to distribute electrical power while as a substitute for the supply of electricity. The tool is an inverter, which is an electronic device that can convert the direct current emanating from devices such as batteries, accumulators or solar cells into alternating current. This tool can work for backup electricity in the house within a certain time (temporarily) when the supply of electricity goes out and over the input voltage of the battery is not discharged. Source voltage of the inverter is the battery or batteries and is only used when needed or as a temporary replacement of National Electrical Power, electricity when subjected to power outages.

2. Literature Review

2.1. Inverter
The inverter is a circuit that functions to convert a DC input to AC output voltage and frequency can be set as desired. Alternating voltage square waveform and in particular the use of the necessary filters
to produce a sinusoidal waveform. Great setting voltage can be done in 2 ways. Firstly by regulating the DC input voltage from the outside but wide fixed ignition timing. Second, set the width of the time to connect with the DC input voltage remains.

The inverter is composed of the main circuit formed by the rectifier circuit whether controlled or not to convert the alternating current (AC) into direct current (DC) and eliminates the ripple contained on direct current. The rectifier serves as a charger voltage on the battery/accumulator when the voltage source inverter from the battery has been depleted. To prevent damage to the battery due to overcharger, then you should add automatic circuit rectifier circuit that will decide the filling process when the voltage on the battery is full [3][4]. Chart inverters generally have a shape like in Figure 1.

![Figure 1. Chart Inverter](image)

### 2.2. Inverter structure

The structure of the inverter (Figure 2) shows that the inverter with transistors that produces an alternating current (AC) with the frequency of commercial sources, (50 Hz or 60 Hz). The first part of the circuit converter (which converts a source of commercial AC into DC source and eliminates the ripple on the DC output. The second circuit is an inverter that converts the direct current into alternating current three-phase with frequency diverse (adjustable); the circuit is called the primary circuit. The third part is a control circuit that serves as a controller of the main circuit. The combined total of the circuits is called an inverter.

![Figure 2. Structure simple inverter](image)

When the position of S1 and S2 in A, the burden of getting a positive voltage, while a negative voltage is obtained when S1 and S2 in position B. Thus the removal of the switch (S1 and S2) in turn will generate alternating voltage is a square which is determined by the source, and the frequency is determined by the switching speed switch. Based on inverter configuration can be differentiated into two types namely single-phase half-bridge inverter and single inverter phase full bridge [5]. Meanwhile, based on the number phase, the inverter can be divided into two types as well that inverters single-phase and three-phase inverter.
2.3. Energy Saving Light Bulb

The energy-saving lamp is a type of fluorescent lamp with the development of a compact form. Energy-saving lamps have the same working principle with fluorescent lighting, which is casting the gas in the lamp tube causing ultraviolet rays due to electrical energy flow. The type often used is a model of soft light (SL) and power light (PL). In the SL models electric component consisting of ballasts, capacitors, and integrated starter in unity in the lamp, while the PL models for electric component separate from the lamp. LHE fundamental differences with standard fluorescent lamps are lamps that have been designed to the shape of the cap and are made the same as at the foot of incandescent lamps is by the screw system [6]. The advantages of energy-saving lamps are the use of electric power is more efficient than incandescent bulbs and TL; and It has a service life span is longer, which is about 8 times the service life of incandescent lamps.

2.4. Inverter efficiency

Inverter efficiency illustrates the effectiveness of the conversion of the inverter to convert direct current into alternating current, efficiency is influenced by the amount of output power and magnitude of reactive power, reactive power is the real power losses in system and loss as much as possible in the system, in order to shrink the more efficient. Large reactive power is influenced by the power factor.

3. Methodology

As for the equipment used in this study are as follows:
1) Single-phase inverter, as transformers DC to AC that will be examined use.
2) Energy Saving Lamp types SL, as an electrical load that will weigh on the inverter which these lights are arranged in parallel and power consumption varies greatly.
3) Accumulators, as a DC voltage source to power the inverter.
4) Rectifier (charger), used as auxiliary equipment when the voltage needed for charging the accumulator.
5) Ammeter AC and DC used to measure the flow of inputs and outputs on the circuit.
6) The multimeter is used to measure the voltage on the circuit.
7) The electronic energy meter, used as a measure of power and cos phi load.
8) Jumper cables, as the connecting terminals on the circuit.
9) Camera (mobile), used to perpetuate research on the indicators to be studied.

The study was conducted through several stages of testing, measurement and measurement are as follows:
1) Prepare all the equipment that will be used in this study.
2) Ensuring that the accumulator would be used in full condition and ready for use.
3) Connecting the DC ammeter in series with the positive terminal of the accumulator and the positive input terminal of the inverter.
4) Connecting in parallel a DC voltmeter (multimeter) to the accumulator terminal and inverter input terminal.
5) Large measure voltages and currents that occur in large measure input voltage inverter and the inverter output when the inverter in case of no load.
6) Connect in series ammeters AC (can be replaced by a power meter) to one inverter output terminals and one terminal (cable) load energy-saving lamps.
7) Connect in parallel AC voltmeter (multimeter) and frequency meter with inverter output terminals and terminal (cable) load energy-saving lamps.
8) Turning on the inverter with the state of load is a load with a large energy-saving light bulbs predetermined power (starting from the smallest lamp power to the largest).
9) Measuring the large input voltage inverter, inverter input current, the output voltage of the inverter, inverter output current, frequency and power factor of the inverter in case of the load.
10) Doing repetitive experiments (8) and (9) to load a large energy-saving lamp with the other lamp power (lamp power is raised varies to the extent desired).

11) Noting the results of measurements of indicators that have been obtained at the study table.

12) When it has finished, then measure the whole load on the inverter, inverter shutoff, releasing all the test series that have been assembled in advance and store the equipment back in place of the original.

13) Conduct analysis of the calculation of some indicators that can not be obtained through measurement, such as counting much voltage ignition inverters based on the signal waveform, substantial average voltage, the effective voltage, power input and power output of the inverter and the inverter efficiency at light load with various power, did calculation of the duration of the charging current for the accumulator and the duration of use of the accumulator on the inverter.

14) Record all calculation results obtained in the chapter on data analysis and discussion.

4. Results and Discussion

In testing with this load, several energy-saving bulbs are used starting from 5W to 203W to overload a 12V accumulator with a maximum current output rate of 65Ah. The schematic form of mounting measuring tools, accumulators, and lights on the test can be seen in Figure 3 and Figure 4.

![Figure 3. Schematic Inverter with Load Tests](image)

Inverter with load testing aims to determine the magnitude of the voltage and current input from the accumulator as well as to determine the amount of voltage, current consumption, power factor, and frequency generated by the inverter after getting a load of energy-saving lamps[2][7].

![Figure 4. Load Testing Inverter with Energy Saving Light Bulb](image)
The comparison of power factor saving lamps based on inverter brings much difference to the result, the load using an inverter much better, compared with power factor the light load without using an inverter [2][8] (Figure 5).

Figure 5. Comparison of the chart again power factor using an inverter and without inverter

From data testing of Inverter (Figure 5), we can calculation, input power, the power consumed by energy-saving lamps, out power, reactive power, and efficiency we will get the results as in Table 1.

| Load (W) | P supply (W) | S load (VA) | P load (W) | Q load (VAR) | Eff (%) |
|---------|--------------|-------------|------------|--------------|---------|
| 5       | 5.06         | 7.38        | 4.79       | 5.61         | 94.66   |
| 13      | 12.81        | 17.06       | 12.11      | 11.94        | 94.53   |
| 24      | 23.86        | 26.52       | 22.54      | 14.06        | 94.46   |
| 38      | 35.18        | 38.08       | 33.13      | 18.66        | 94.17   |
| 56      | 50.87        | 53.66       | 47.75      | 24.68        | 93.86   |
| 74      | 62.34        | 64.01       | 58.24      | 26.24        | 93.42   |
| 97      | 78.61        | 80.32       | 73.08      | 32.93        | 92.96   |
| 123     | 97.24        | 97.47       | 89.67      | 38.01        | 92.21   |
| 158     | 123.17       | 121.09      | 112.59     | 44.79        | 91.41   |
| 203     | 149.78       | 145.84      | 135.63     | 53.96        | 90.55   |

From the above calculation results obtained when the inverter efficiency energy-saving lamps burdened with a load varied from 5 watts to 203 watts was obtained efficiency of 94.66 - 90.55 %

5. Conclusion
The load using inverter it can be concluded reactive power smaller only 53.96 VAR, and power factor during the height load is 203 watts used power factor better 0.93, consumption active power lamps are very good 135.65 Watt, and inverter efficiency in doing the convert direct current to alternating current during low load (5W) amounted to 94.66% and the highest load current (203W) amounted to 90.55%, it means using inverter can increase the value of efficiency.

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