Studies in Philosophy of Science and Education
Homepage: https://scie-journal.com/index.php/SiPoSE
Email: sipose@scie-journal.com

p-ISSN: 2722-3523; e-ISSN: 2721-9267
SiPoSE, Vol. 2, No. 3, November 2021: 84-94
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# Implementation of Physics Concepts in Energy Conversion-Based Electronic Devices as Physics Teaching Materials

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**Article Info**

***Article history:***

Received 2 August 2021
Revised 20 August 2021
Accepted 24 November 2021
Available Online 31 November 2021

***Keywords:***

Electric scooter
Energy convertion
Physics teaching materials
Solar panel lights
Water heater

**ABSTRACT**

This study aims to analyze the concepts of physics in electric scooters, solar panel street lights, and water heaters as physics teaching materials. The research method used in this research is a qualitative method with literature study. Data collection techniques in this study consisted of observation and documentation. Observation is done by observing directly and then documented. The data analysis technique used is to perform data reduction and then draw conclusions. The results obtained are the concepts related to scooters, solar panel street lights, and water heaters are the principles of energy conversion, direct electricity, and heat. In an electric scooter, energy conversion occurs from electrical energy into motion energy, a solar panel street light converts solar energy into electrical energy, and a water heater converts electrical energy into heat energy. That way, it can be an alternative teaching material in learning with concrete examples in the surrounding environment. So that it can make the learning process more meaningful.

https://doi.org/10.46627/sipose

## INTRODUCTION

Nowadays, technology is developing rapidly and competition is getting tougher. This is because we live in the era of the 21st century. An absolute must for every country to win the competition in the 21st century is to prepare highly competitive human resources (Wahyuni et al., 2021). In addition, the industrial revolution 4.0 is also looking for references to improve the quality of human resources (HR). According to Lase (2019), explaining that the industrial revolution 4.0 is marked by increased connectivity, interaction and development of digital, artificial and virtual students. Preparing superior human resources can be done by making improvements in important sectors such as education. The education system used at this time is the 2013 Curriculum which is expected to be able to change education to be more active, creative, and create critical thinking processes and be able to keep up with the times (Dywan & Airlanda, 2020). In addition, teachers have a role that is a benchmark for a country's success in facing the 4.0 revolution (Lase, 2019).

The response to the needs of the industrial revolution 4.0 occurs when humans and technology are aligned to create new opportunities with creative and innovative ideas, which is the meaning of education 4.0 (Lase, 2019). Education in Indonesia is able to survive in the industrial revolution era if it implements the 21st century learning objectives, namely 4C (Rohida, 2018). The 4C components in question are critical thinking, communication, collaboration, creativity and innovation (Makrus et al., 2018; Septikasari & Frasandy, 2018). The number of

DOI : https://doi.org/10.46627/sipose.v2i3.157

technologies that are currently developing cannot be separated from the use of physics concepts in it. Almost all objects circulating today use technology with physics concepts, even simple concepts can be applied. This is because of all the objects in circulation there are objects that use innovations to be environmentally friendly, one of which is the use of electricity in these objects. One of the physics materials is about work and energy (Mukhlis & Judianti 2017). According to Husna et al (2019), it is explained that the matter of work and energy is material that is related to everyday life. The material is certainly related to energy conversion. The purpose of this study was to analyze the concepts of physics in electric scooters, solar panel street lights, and water heaters as physics teaching materials.

## RESEARCH METHOD

This research was conducted using a qualitative method in the form of a literature study. According to Nana (2018), explaining that by using the literature study method, data is collected for analysis and then presented in the results of the discussion so that conclusions can be drawn. Data collection techniques in this study consisted of observation and documentation. Observations were carried out in big cities in East Java, including the cities of Madiun and Surabaya by observing directly and then documented.

There are two sources of data used in this study, namely primary data and secondary data. Primary data is in the form of data obtained during observations while secondary data is obtained by conducting library research through journals and books. The data analysis technique used is to perform data reduction and then draw conclusions. According to Nurhidayat, et al (2020) explaining that using data reduction can allow researchers to analyze initial data into data that is more relevant to the research objectives. The research flow is described as follows.

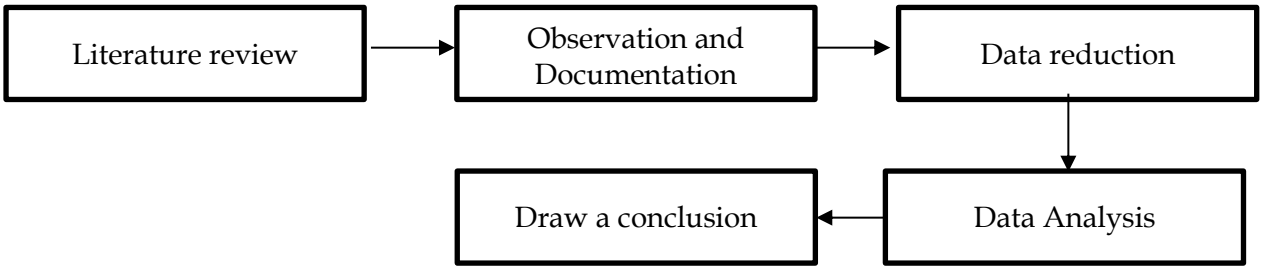



**Diagram 1.** Research flowchart

## RESULTS AND DISCUSSION

### Energy

Energy in technical and physical knowledge can be defined as the ability to do work. Energy in nature is constant (first law of thermodynamics). Energy cannot be created or destroyed, but can be transformed or transformed from one form of energy to another. Energy can also be transferred from one system to another by a force that causes a change in the position of an object. This energy transfer is the ability of a system to produce work that positively affects human needs. So energy is a quantity that is conserved, can change form, and can move from one system to another, but the total amount is constant (Pratomo, 2013).

A system is said to have energy if the system has the ability to do work. The amount of energy of a system is equal to the amount of work that can be generated by the system. Therefore, the unit of energy is the same as the unit of work and energy is also a scalar quantity (work-energy principle: work is the transfer of energy by the forces acting on objects) (Serway and Jawett, 2014). In physics there is energy that can be classified as follows.

### Mechanical Energy

Mechanical Energy (*Em*) is the sum of the kinetic energy and potential energy of an object.

$$Em=Ek+Ep \qquad (1)$$

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Because energy can neither be created nor destroyed or energy is conserved, the law of conservation of energy applies. The value of the context discussed is mechanical energy, so the conservation of mechanical energy is written (Serway & Jawett, 2014).

$$Em_1=Em_2 \qquad (2)$$
$$Ek_1+Ep_1=Ek_2+Ep_2$$

Kinetic energy is the energy possessed by any moving object. The kinetic energy of an object is directly proportional to the mass of the object and the square of its velocity.

$$Ek=\frac{1}{2}mv^2 \qquad (3)$$

with,
$Ek$ = Kinetic energy (joule)
$m$ = object mass (kg)
$v$ = velocity (m/s)
effort = change in kinetic energy.
$W = \Delta Ek = Ek_2 - Ek_1$

From this equation, the work of a moving object is the change / difference between the final kinetic energy and the initial kinetic energy of the moving object. Gravitational potential energy is the energy possessed by an object due to the influence of its place (position).

This potential energy is also called rest energy, because even objects at rest can have potential energy.

$$Ep = w.h = m.g.h \qquad (4)$$

with:
$Ep$ = potential energy (joule)
$w$ = weight (N)
$m$ = object mass (kg)
$g$ = acceleration due to gravity (m/s$^2$)
$h$ = height (m)

The gravitational potential energy depends on the gravitational acceleration of the earth and the position of the object, and the mass of the object.

**Electrical energy**

Electrical energy is energy associated with the accumulation of electron currents, in the form of transitions or transfers, where electrons flow through some type of conductor. Electrical energy can be stored as electrostatic field energy and is the energy associated with the electric field due to the accumulation of electronic charges on the capacitor plates. The energy of the electric field is equivalent to the energy of the electromagnetic field which is equal to the energy associated with the magnetic field created by the flow of electrons through the induction coil**.** (Pratomo, 2013).

Electrical energy is denoted by W. While the formula used to determine the amount of electrical energy is:

$$W = Q.V \qquad (5)$$

with,
W = Electrical energy (Joule)
Q = Electrical charge (Coulomb)
V = Potential difference (Volt)

Energy stored in electric current in amperes (A) and voltage in volts (V) with the provision of electrical power consumption in watts (W) to drive motors, lighting, heating, cooling or re-moving a mechanical device for produce other forms of energy

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The existence of this electrical energy can be utilized as much as possible. The energy used by an electric tool is the rate of use of energy (power) multiplied by the time during which the tool is used. When power is measured in watt hours, then:

$$W = P.t \qquad (6)$$

with,
P = power (watt)
t = time (h)
W = effort (wh)

**Energy Conversion Principle**

Energy in the knowledge of technology and physics can be defined as the ability to do work. Energy in nature is a constant quantity (first law of thermodynamics). Energy cannot be created and cannot be destroyed, but it can be converted from one form of energy to another, for example on a stove in the kitchen, the energy stored in kerosene is converted into fire. Furthermore, if fire is used to heat water in a pan, the energy is transformed again into the motion of water molecules. This change in the form of energy is called conversion. While the transfer of energy due to a difference in temperature is called heat. Energy can also be transferred from one system to another through a force that causes a shift in the position of objects. This transfer of energy is the ability of a system to produce work that has a positive effect on human needs. So energy is a quantity that is conserved, can change form, and can move from one system to another, but the total amount is constant.

**Electric Scooter**

Electrical energy can be converted into mechanical energy or motion. Like the opposite of mechanical energy converted into electrical energy. One of the tools that convert electrical energy into motion energy is an electric scooter. On an electric scooter, an electric current flows through the coil, to create a magnetic field, so that the axle can rotate, the rotation of the axle is used to drive fans, electric drills, and other tools. In electric scooters, electric power is converted into mechanical energy. This change is done by converting electric power into a magnet which is known as an electro magnet. As we know that the same poles of a magnet will repel and different poles will attract. So we can get motion if we place a magnet on a rotating axis, and the other magnet in a fixed position. Observations on the use of electric scooters were carried out in the Surabaya area, precisely on Tunjungan Street



**Figure 1**. Electric Scooter

The components of an electric scooter are simpler than an electric motorcycle. Generally, the components of an electric scooter only consist of a battery, motor generator, power inverter, controller and charger.

DOI : https://doi.org/10.46627/sipose.v2i3.157

1. Batteries, batteries have a function as an energy storage system in the form of direct current electricity. When the battery gets a signal from the controller, the battery will supply DC electricity to the inverter which is then used to drive the motor*Motor generator*, because controller supplies power from battery, generator motor will work to rotate wheels.
2. Power Inverter, The inverter is part of the DC direct current converter system in the battery into AC alternating current which is then used by the traction motor. The inverter also functions to convert AC current during regenerative braking into DC current which then functions to charge the battery again.
3. Controller, the main function of the controller is as a component element of the battery energy regulator and the next inverter is channeled to the motor generator. While the controller itself gets the main input from the gas response. This gas response setting will determine the variation of the frequency or the variation of the incoming voltage to the motor generator as well as determine the speed of the vehicle.
4. *Charger*, this function is as a component of battery charging equipment.

**Solar Panel Street Lights**



**Figure 2**. Solar Panel Street Lights

Solar panel-based street lighting requires several main components, namely solar panels, batteries, lights, and charge control (battery charger regulator). Calculation of solar panelcapacity to match the output load, can use the equation

$$P_{\text{solar panels}} = \frac{ET}{solar\ insonance} \qquad (7)$$

Where the solar panel is the panel power (Wp), BUT is the power usage (Wh) and solar insonation is the effective time of sunlight per day. The battery is a component that functions to produce dc current electrical energy in the solar system. Electrical energy in the battery is generated by solar panels which convert sunlight into electrical energy. The size of the battery capacity is in ampere hour (Ah). Calculation of battery capacity to fit solar panels and output load can be calculated using.

$$Ah = \frac{ET}{V} \qquad (8)$$

where *Ah* is the battery power (Ah), V is the battery voltage used (volts).

The lamp is a component that functions to produce light. The type of lamp used is a dc lamp. The use of dc lamps is due to the fact that the street lighting system does not use an inventer. Solar system-based street lighting uses an output in the form of dc lamps with a power of 12

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Watts, and usage for 12 hours/day. Then the power required to turn on the dc lamp per day is 144 Wh. DC lamp used as a source of lighting. Charge control is a component that functions to regulate electrical energy from the solar panel to the battery, and regulates electrical energy from the battery to the dc lamp. Charge control is a gateway for electrical energy between solar panels-battery-dc lamps. The use of charge control in the street lighting system causes electrical energy from the solar panels to enter/charge the battery, and keeps the battery from being overcharged. In addition, charge control causes electrical energy from the battery to be channeled to the dc lamp so that the dc lamp can turn on. The setting of electrical energy from the battery to the dc lamp can be regulated by the charge control, so that the on/off time of the lamp corresponds to the desired time. The charge control capacity measure is used in amperes (A).

$$Imax = \frac{Pmax}{Vs} \qquad (9)$$

where Imax is the current capacity of charge control (A), Pmax is the capacity of the solar panel (W), and vs is the voltage of the solar panel (V).

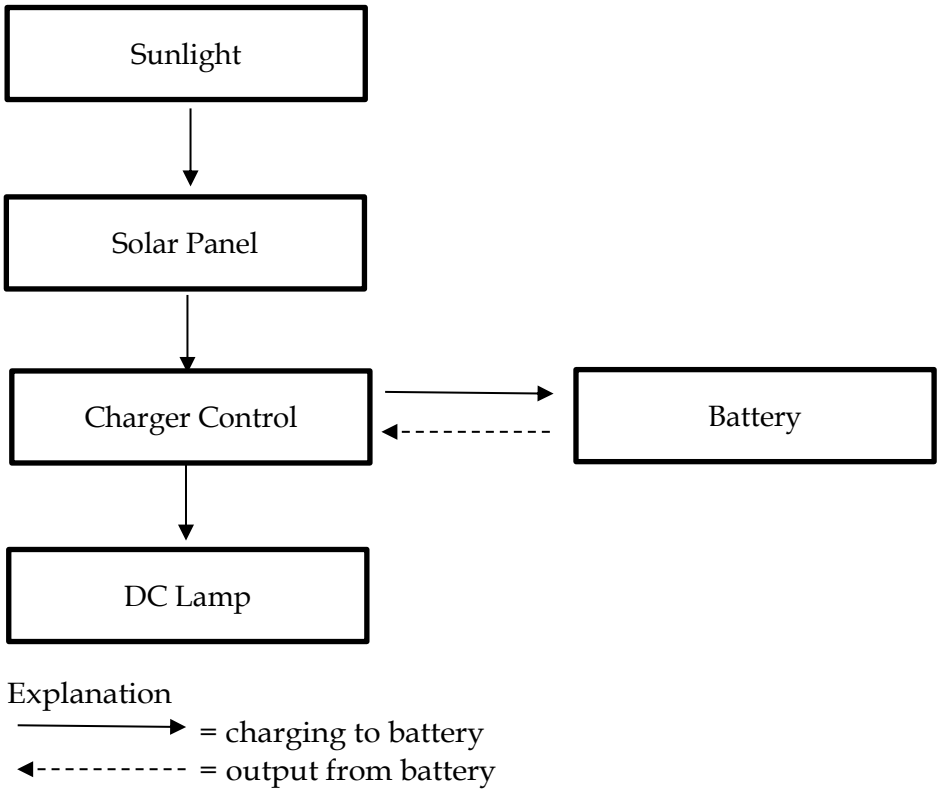



**Figure 3**. The working principle of the solar panel-based light circuit

The working principle of a series of solar panel-based street lighting in general is:

1. Solar panels capture sunlight which then converts into electrical energy to fill energy needs in the battery with the help of charge control.
2. Electrical energy from the battery will be used to turn on the dc lamp on charge control command.
3. The start time of the dc lamp ignition based on the command from the charge control when the solar panel really does not get sunlight (twilight/night conditions).
4. The duration of the ignition of the dc lamp is also based on the settings in the charge control, so that the lighting can be turned on automatically.

Solar panels are devices or devices consisting of solar cells that convert sunlight into electrical energy. Of course, solar panels have the basic function of a generator, converting solar energy

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into electrical energy. The purpose of photovoltaic itself is to convert light energy directly into electricity by using the photoelectric effect. The power generated by solar panels is direct current (DC). Therefore, to power most household electronic equipment, which mostly uses alternating current (AC) power, an inverter is used to convert direct current into alternating current. (Sundari, P. 2018). According to Tohari (2020), the solar panel used is a 100 wp plycystalline solar module. where this solar panel is capable of producing 100 watts of watts, and the voltage generated from this solarland polycrystalline solar panel is 12 volts. This is in accordance with the use of LED lamps with an output of 50 watts. In addition to the compatibility of the wattage of the LED lamps used, Solarland's choice of solar panels with solar panels is solar with a SiN coating which provides a solution for power needs to save electrical energy. applications such as solar home systems, PJU Solar Power, centralized PLTS.

LED stands for light emitting diode, which is a semiconductor that emits a bright color (one color) in the form of electromagnetic light (coherent) when a forward voltage is applied. This phenomenon is called electroluminescence because the color emitted by this LED bulb depends on the material used in the semiconductor. The LED lamp used is a 50 watt 4500 lumen LED. Since LED lamps consume less energy than traditional lamps, the use of 50 watt LED lamps is considered as an alternative solution for saving the cost of using daily electrical energy. Observations on the use of solar panels were carried out in the Surabaya area, precisely on Jalan Kebonsari.

**Water Vapour On Water Heater**

The invention of thermoelectricity is based on the discoveries of various scientists. In 1821, Thomas Johann Seaback conducted an experiment showing that electromotive force can be generated by heating the ends of two different conductors and the ends of the other conductors being joined (Goldsmid, 2009). In 1834, 13 years after the discovery of the seaback effect, J. Pelche discovered the opposite of the seaback effect. The two metals which are connected when an electric current is applied produce a relatively small cooling or heating effect, depending on the direction of the current. This phenomenon is called the Peltier effect. (Rimbawati, R. 2022).

In this picture, water is added to the water heater, then the water heater is turned on using electricity which will produce water vapor. At a certain temperature and pressure, evaporation occurs in all parts of the liquid. This complete evaporation is called boiling. At the time of boiling the temperature of the substance is constant, because during the boiling of water the heat absorbed is used to convert water into water vapor.



**Image 4**. Water Vapour On Water Heater

The heat given to a substance is used to change its state from a liquid to a vapor state. This constant temperature is called the boiling point, which depends on the pressure at the surface of the substance. The boiling point of a substance at a pressure of 1 atm is called the normal boiling point. The heat required to change the state of 1 kg of a liquid into a vapor at its normal boiling

DOI : https://doi.org/10.46627/sipose.v2i3.157

point is called the latent heat of vapor or vapor heat. The heat of vapor is also known as the boiling heat. When a substance changes from a gas to a liquid, it releases heat. Observation of the use of an electric water heater was carried out at the house of one of the authors.

Based on the explanation above, the concepts contained in electric scooters, solar panel street lights, and water heaters are the deepest material in energy conversion in the topic of business and energy. If it is integrated into physics learning in accordance with basic competencies (KD) according to K13, it is presented in Table 1.

**Table 1**. The relationship between the concept of physics and KD K13

| Physics concept | KD K13 |
|---|---|
| Energy convertion | 3.9 Analyze the concept of energy, work (work), the relationship of business (work) and energy changes, the law of conservation of energy, and its application in everyday life |
| Heat | 3.5 analyze the effect of heat and heat transfer which includes the thermal characteristics of a material, capacity, and heat conductivity in everyday life. |
| Direct electricity | 3.1 analyze the working principle of DC electrical equipment and its safety in everyday life. |

Based on Table 1, the implementation of physics concepts in energy conversion-based electronic devices can be integrated into learning. this can be strengthened from the relationship between the physics concepts used and the basic competencies in K13. One of the integrations is to use STEAM, because by using the STEM approach students can be actively involved in critical thinking, investigation, problem solving, collaboration, and engineering as design thinking (Torlakson, 2014). In addition, using this approach can be in line with the objectives of the 2013 curriculum which is student-centered learning (Hidayah et al., 2020; Pertiwi et al., 2022; Prasetyawati, 2016). This is also strengthened because the STEM approach is in accordance with science learning which equips students with various disciplines and develops thinking power (Pamungkas et al., 2019).

**Implementation of Physics Concepts in Energy Conversion-Based Electronic Devices**

To find out in more detail about how to implement the concept of physics in energy conversion-based electronic devices, it is necessary to review several articles that discuss their implementation so that the information obtained is truly valid. The following review results are shown in Table 2.

**Tabel 2**. Implementation of physics concepts in energy conversion-based electronic devices

| Title article | Name | Result | Suggestion |
|---|---|---|---|
| Kajian Teknologi Pada Sepeda Motor Bertenaga Listrik | Mukhlis, A & Judianto, O. (2017) | The results of this study indicate that the design of the electric motor is expected to be able to compete with and not be inferior to the design of a commercial-fueled motor, and to reduce pollution caused by these commercial-fueled vehicles. | The hope in the future is that there will be more designs and users of electric motors. because here the author finds that electric-powered motorcycles are still rarely seen, especially in Indonesia. |
| Modifikasi Sistem Kendali Sepeda Listrik Listrik Hybrid | Huda, N & Khamami, F. (2017) | The results showed that the control system on a hybrid electric bicycle can be made with battery and generator power. From the test, we can compare the work system between a hybrid electric | For further researchers, they can carry out more complex and modern modifications of the electric bicycle control system, besides that they can develop other |

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| Title article | Name | Result | Suggestion |
|---|---|---|---|
| | | bicycle using a controller and a hybrid electric bicycle without using a controller. Every hybrid electric bicycle must have a control system, even though the control system is simple. Electric bicycles can be modified by adding a generator to supply electricity when traveling. | modifications, not only on the control system. |
| Efektivitas Model Pembelajaran *Project Based Learning* Berbasis STEM dan Tidak Berbasis STEM Terhadap Keterampilan Berpikir Kritis Siswa | Dywan, A. A & Airlanda, G. S. (2020) | The use of the STEM-based Project Based Learning model is more effective in improving students' critical thinking skills. This is proven through treatment using a quasi-experimental method. | This study suggests that we continue to develop STEM-based learning with other learning models, this is expected to improve students' abilities and skills. |
| Pengembangan Miniatur Konversi Energi Gerak Sebagai Media Pembelajaran Fisika Konstektual | Husna, D., Yakob, M., & Mustika, D. (2019) | The results of the research obtained are the development of a miniature energy conversion of motion as a contextual physics learning medium that is feasible and interesting if used in learning. this is based on the results of the validation of experts and student responses regarding the development of this miniature. | This article suggests the need to develop learning media in physics subjects. This is expected to help students accept the learning process and make learning more interesting. |

Based on these articles, it is possible to implement the concept of physics in an electronic device based on energy conversion as a learning medium. Although there are still not many who apply it, it can be used as a modification and development so that the physics learning process can be more diverse and interesting for students.

## CONCLUSION

Based on the results of the analysis above, it can be concluded that in electric scooters, solar panel street lights, and water heaters, there are several physical concepts, namely energy conversion, direct electricity, and heat. That way, the concepts obtained can be used as teaching materials so that students better understand and experience concrete and meaningful learning. Suggestions for future researchers are expected to further deepen the concepts of physics and even other subjects found in the application in everyday life. In addition, it can develop other research in types of technology so that it can add insight and knowledge.

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