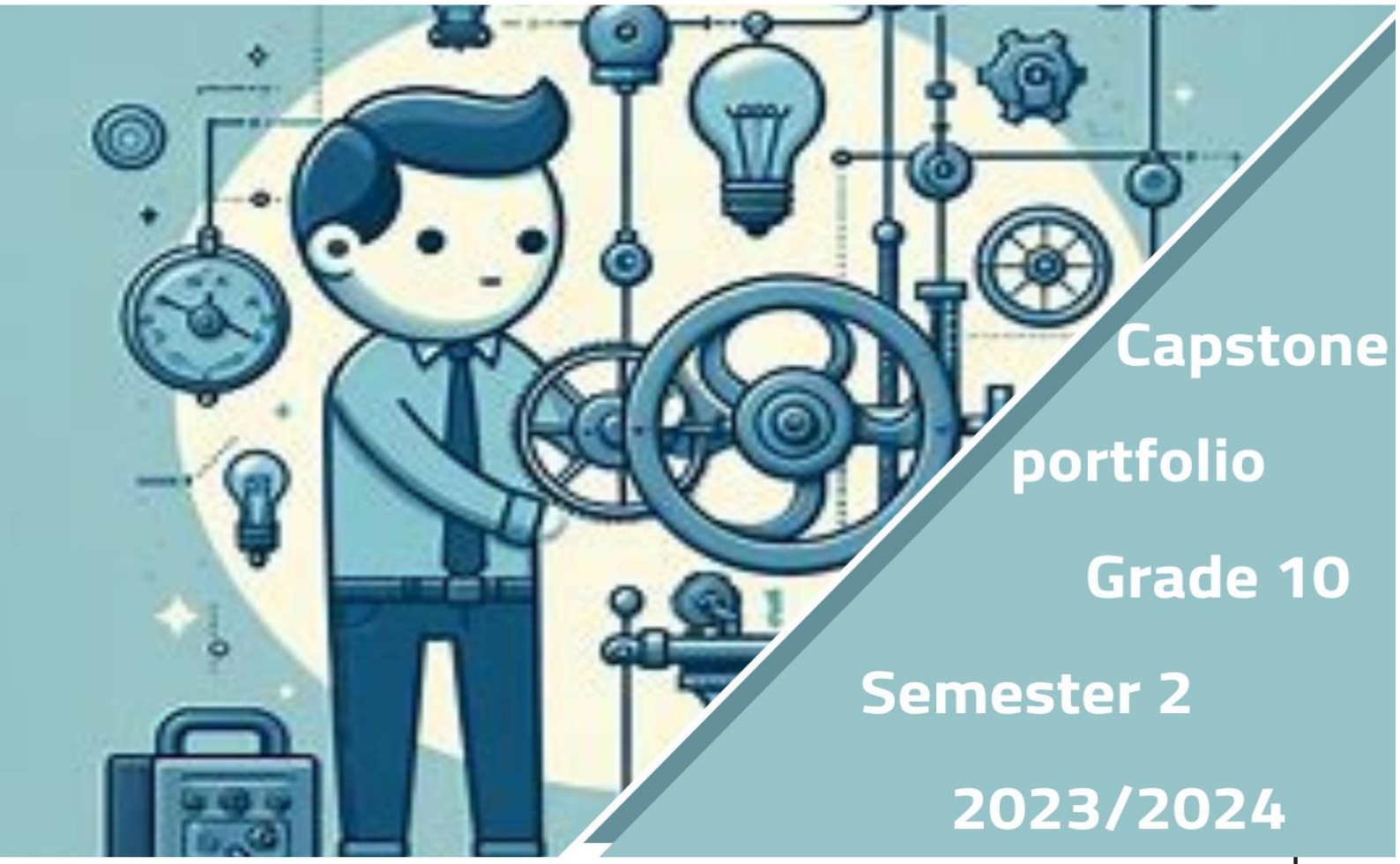
CONVERTING THERMAL AND MECHANICAL ENERGY INTO ELECTRICITY USING STIRLING ENGINE



Capstone portfolio

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Contents

Egypt grand challenges

For the last few years, Egypt faced many challenges that became obstacles to its development, and the government has tried hard to solve these problems to continue on its road to success and improvement in many fields.
Defining these problems is necessary to solve them, as there are too many challenges, the economic researchers chose 12 challenges to be the main grand challenges in Egypt and focus on solving them as they include the most important fields in Egypt.

These 12 main grand challenges are shown below:

- Deal with exponential population growth
- Reduce pollution.
- Work to eradicate public health issues.
- Improve the use of alternative energies.
- Reduce urban congestion.
- Reduce and adapt the effects of climate change.
- Improve the use of arid areas.
- Increase industrial base for Egypt.
- Improve sources of clean water
- Increase opportunities for Egyptians to stay and work in Egypt.
- Recycle and retain garbage for recycling.
- Improve the scientific and technological environment for all.

Improve the usage of alternative energies

One of the most necessary goals in the 21st century is to stop depending on fossil fuels as a main source of energy. Each country in the world is trying its best to achieve this goal. As fossil fuels are not renewable sources of energy, the world could run out of energy if it keeps depending on these sources. Also, as they have an enormous negative impact on the environment, causing disasters like global warming and melting of the poles. The whole world now is racing to get alternative sources of energy to avoid the disasters that could happen if they continue depending on fossil fuels.

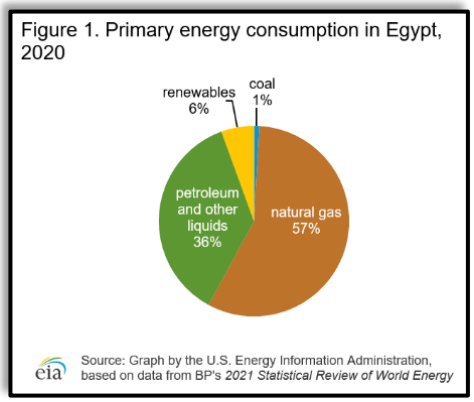
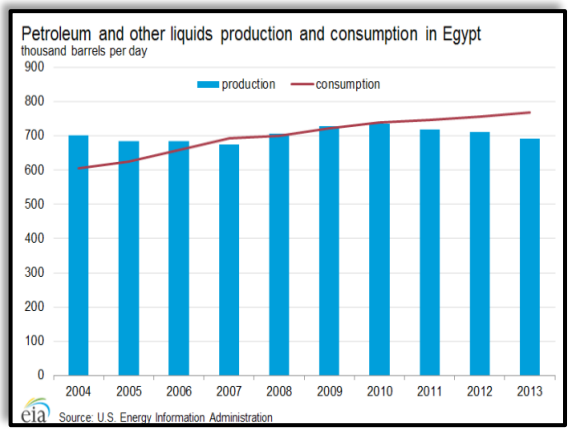


Figure 1

For Egypt, the government is trying to produce new types of energy to use, but Egypt's usage of renewable energy in 2020 was just about 6% of the total energy usage, which is a very dangerous number, as it shows that the country is still depending on using fossil fuels as the main source with the 94% of the total energy usage. ***As shown in figure (1)***

Furthermore, one of the main sources of energy in Egypt is oil, Egypt's total production of oil in 2015 was 680,000 bbl/day1, this is a large number that tells that Egypt doesn't have an oil shortage, Egypt also has the largest refinery capacity in Africa, we can conclude from these indicators that Egypt



Graph 1

should have self-sufficiency of oil, but Egypt is the largest oil consumer in Africa, as it accounts about 20% of the continent oil consumption, also, there is an annual increasing in the country's

consumption of oil with about 3%. So, Egypt is an importer of oil because the consumption is greater than the production ***as shown in graph (1).***

In the last few years, some events happened in the world, having great effects on the Egyptian economy, and having a great impact on the energy sources in Egypt, one of these events is the war in Gaza Strib. As Egypt has borders with the Israelian occupation lands, and there is an economic relation between them, so Egypt has a big relation to this war, and its economy is affected Significantly by this issue.

Figure 2 (shows the halted gas field in Israeli Tama

a lot of gas fields in Israel stopped working because of the war in Gaza and Hamas attacks, like the Tamar field in the Israelian coasts that halted production on 7th October 2023 ***which is shown in figure (2).*** Israelian gas from the Tamar field was being exported to Egypt through pipelines. Halting this gas field had an impact on the energy in Egypt, the fuel prices increased by 15%, and the estimations indicate that Egypt will face a sharp decrease in the exported gas to it by about 70%, these can be indicators that Egypt is facing an enormous problem in its sources of energy.

As a result of this, internal problems occurred in Egypt, as the government started to make daily cutbacks to decrease the consumption of electricity, which was not accepted by the Egyptian citizens and created other problems for them.

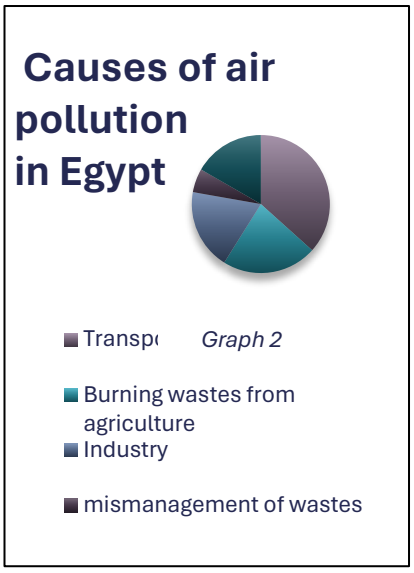
To summarize, the Egyptian energy issues are increasing year after year, and the government must make decisions to decrease it, and stop depending on fossil fuels that the world could run out of causing the crisis, and the best way to do this by creating new sources of clean renewable energy.

Reduce pollution

One of the most important problems that face the world is Pollution. Increasing pollution in Egypt risks a lot of people's lives. There are many types of pollution such as air pollution and water pollution. The most common type of pollution that Egypt suffers from is air pollution.

Air pollution

Air pollution has been a problem for decades in Egypt. Air pollution was the cause of 90.559 premature deaths in Egypt in 2019, which is more than road injuries and diabetes. The current air quality in big cities in Egypt like Cairo is poor, and that is because of bad human actions and habits.



Graph 2

The causes of air pollution in Egypt:

1)Transport

2)Burning wastes from agriculture

3)Industry

4)mismanagement wastes

As shown in Graph (2).

Many other resources pollute the air of Egypt.


Figure 3 (air pollution in Egypt)

The first cause is (transport). The traffic in Cairo has reached 80% of the congestion problem. Traffic volume can reach 7,000 vehicles per hour per lane, which makes a huge amount of greenhouse gases.

Burning the waste of agriculture is a practice that has increased because of the increase of agricultural areas near the valley of the

Nile. 500,000 tons of straw had been collected in 2020 by the government, which is 90% of the production.

Industrial power is the third-highest concentration of pollution in Cairo. The factories' lands that are separated in many different places are causing air pollution by the gases and the smoke that they produce in working, most of these industries are naturally based, but the way of using it harms the air.

Water pollution

The Nile River is the main source of water in Egypt. The river is continuously contaminated with overwhelming amounts of items such as discharge, toxic chemicals, fertilizer residue, radioactive waste, and oil pollution is truly horrific and dangerously deadly. Egyptian traditions can be considered a large cause of water pollution. The pollution of the Nile is one of the most serious issues that faces Egypt.

Figure 4 (water pollution in Egypt)

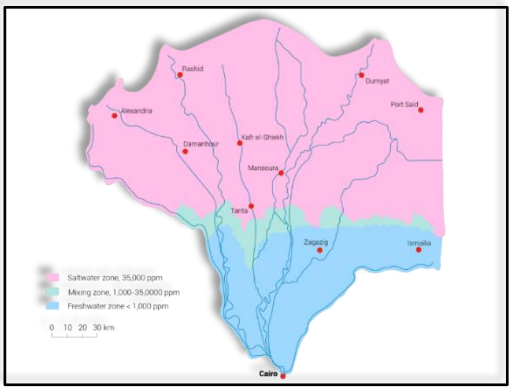


Figure 5

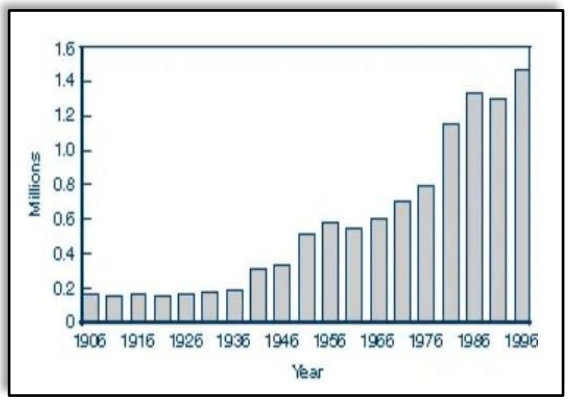
About 4BCM of agriculture and industrial wastes containing acids, organic materials, and heavy metals are discharged into the Nile and its branches. Iron and manganese concentrations in the delta reach 1,600 µg/liter and 220 µg/liter, respectively. The activities of polluted water in the delta have led to an increase in the concentration of chemical nutrients such as nitrogen.

Climate change and sea level rise made a problem, which is the seawater infiltration to the Delta region by allowing vast quantities of saltwater to penetrate the depths of the adjacent aquifers. The groundwater in the Nile Valley is often of higher quality than that in

the Nile Delta. At a depth of 300 meters, seawater has surged to Mansoura, which is approximately 70 km from the coast.

We will try to help the world to reduce any kind of pollution.

Reduce urban congestion



Graph 3

The population had increased in the past 10 years by about 25 million people with a ratio of about 2% annually **as shown in graph (3)** Egypt's birth rate was around 23.7 births per 1,000 people annually, and the population was approximately 104 million while in the other hand, there is only about 19 deaths for each 1000 birth and that leads to increase in Egypt's population and it's expected to be projected to reach 117 million by 2030.

That increase can be due to a lot of factors one of them is the wrong culture and traditions that make the people want to have larger families and the high birth rate, the average Egyptian woman would give birth to 3.4 children in her lifetime and the consequences are showed in a lot of aspects, one of them is the pressure on the country to provide food, water, and land.

Another is the Declining death rate, health care in Egypt has increased over the several last years, so the number of deaths decreased.

Another factor is Increasing healthcare efficiency due to the country's efforts in developing the infrastructure of healthcare and the adoption of healthcare information technology such as electronic health records (EHRs) and telemedicine solutions.

Those factors lead to increasing the expected period of life to 73.5 years due to the healthcare that the individual takes during his

lifetime. The increase in the population not necessarily to be bad or had distractive consequences but in Egypt's case the increase in population was happening rapidly without any limiting and that led to destroying Egypt's economy as the greater the population the greater the demand for food. Thus, the gap between the demand and the supply of food

increased, and that gap caused the government to import more food like meat and wheat to meet the needs of the people.

One of the problems of the population in Egypt is the unfair distribution of people, as Cairo held 24.4 million inhabitants in 2018, while Alexandria, the second city of the country, had only 5.2 million, some way ahead of the next in line: Port Said (749,371), Suez (728,180), Ismailia (384,351), Damietta (281,493) and Luxor (242,375) **as shown in fig (6)**, and that lead to lake of a lot of life resource for a high number of people in those cities. One of

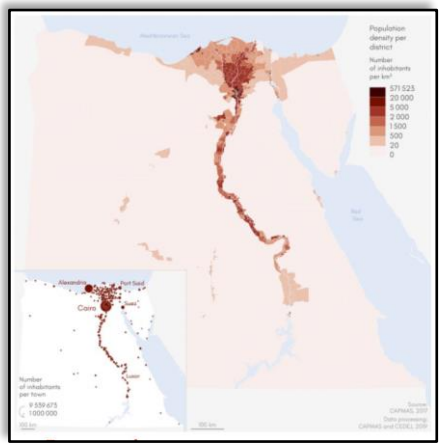


Figure 6

those resources is electricity, as we use oil and natural gas to generate about 93%(36 million tons of oil and 64 billion cubic meters of natural gas) of electricity and that is due to the high number of people that forces the government to use that high quantity of non-renewable sources of energy, that would make consequences to the environment such air pollution due burning the gas and oil, and water pollution due to oil spills and leaks from pipelines, storage facilities, and transportation.

Reduce and adapt the effects of climate change

The change in the earth's climate is called climate change, we can find the effect of climate change at local, regional, or global scales. Climate change is one of the most dangerous problems that the world suffers from.

Climate change increases greenhouse gases (GHGs) in the atmosphere, greenhouse gases include carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) All of these gases lead to the warming of the planet.

Global warming is a word usually used instead of climate change and it is one of the most important indices of global change.

Egypt has had an increase in temperature in the last two decades, according to climate forecasts for Egypt, Egypt will witness a higher level of temperature rise than the global average by the year 2100, and electricity will decrease due to frequent extreme heat events.

-The Human-Driven Causes of Climate Change

Human Activity Is the reason for the increase in Greenhouse Gases (as seen the Figure 7-causes of climate change.) That's because they do that:

1-Burning fossil fuels that are because it has an effect produces and increases carbon dioxide and nitrous oxide.

2- Cutting down forests **(deforestation)** Trees help to reduce climate change and global warming by absorbing CO_2 from the atmosphere, also When they are

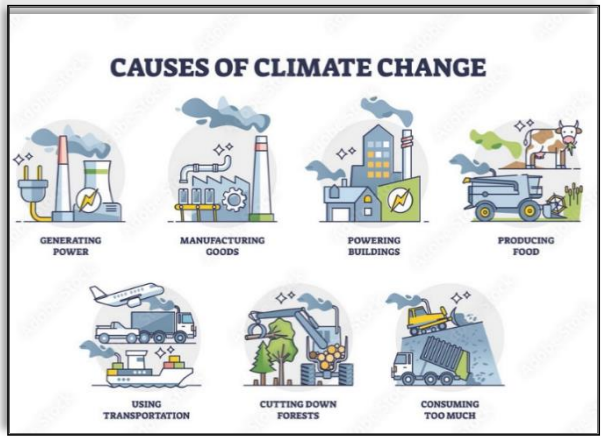


Figure 7 (causes of climate change)

cut down by humans, this benefit is cut off and the carbon stored in the trees is released into the atmosphere.

3-Using transport: Car exhausts increase the CO_2 in the atmosphere

Figure 8 (the effect of climate change)

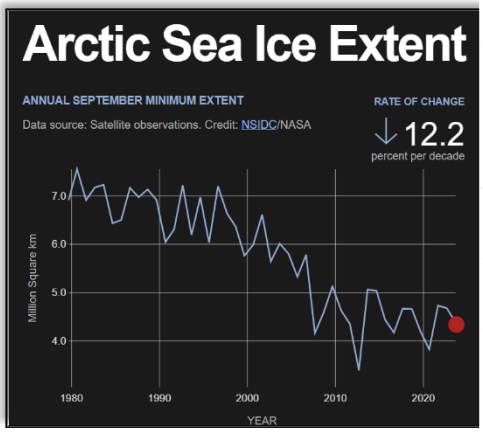
-The Effects of Climate Change

We have already seen some of what is happening to the world because of climate change like:

1-Increasing greenhouse gases: carbon dioxide increased by 423 parts per million, and methane increased by 1923.6 parts per billion.

2-increasing the temperature, the average temperature has been increased by 1.4°c since preindustrial.

3-melting ice then has led to increasing the sea level by 4 inches since 1994 **as shown in figure (8)**



Graph 4 (decreasing arctic sea ice)

4- Climate change led to the killing and extinction of many animals that were living in the cold areas.

5-Arctic sea ice minimum extent decreased by 12.2 percent per decade since 1979 **as shown in graph (4)**

-Future effects of global climate change in the United States

We should stop doing activities that make climate change continue and won't stop because if we Continue doing these activities what will happen:

1-sea level will increase by 8 inches (0.2 meters) By 2100, According to a joint report by NASA and NOAA.

2-More Droughts and Heat Waves will be all seasons are projected to continue to get hotter.

3-Longer Wildfire Season: Warming temperatures have increased and intensified wildfire season in the West.

Improve the scientific and the technological environment for all

Many Developing countries have realized the need for a scientific and technological environment and to focus on developing more extensive knowledge by improving the right environment that integrates both knowledge and economics. Building this knowledge requires a supply of technology. In some countries like Egypt, there is weakness on both of those points. A lot of factors can improve the scientific and technological environment In Egypt like Improving the role of universities, linking between science and commerce, making new research facilities, and having access to the technical facilities. Although there is a huge improvement in the research community in Egypt as there are 120,000 theoretical and applied scientists in 23 government universities and 198 research centers has always harbored great talent also the number of papers published in scientific journals – early indications are good. Egypt's output rose from 4,922 publications in 2006 to 10,295 in 2011 and its global share of publications rose from 0.27% to 0.44%, and its regional share from 8.14% to 9.17%. In 2011, Egypt ranked fourth behind Iran, Turkey, and Israel (17, 19, and 27th global ranking; respectively) among OIC and Middle Eastern countries on the numbers of papers published, yet lies 40th globally, but when you consider the number of papers published per million population, Egypt still looks uncompetitive next

to some Middle East countries like turkey. So, we have not reached yet what we want. So the country decided to improve the previous three factors in an try to improve the scientific and technological environment.

Improve the role of universities: Egypt made an organization called The National Council for Education and Scientific Research (NCESR) which is a group of university professors who are reselected every three years whose aim is to determine Egypt's developmental priorities and how they should be supported by education and science

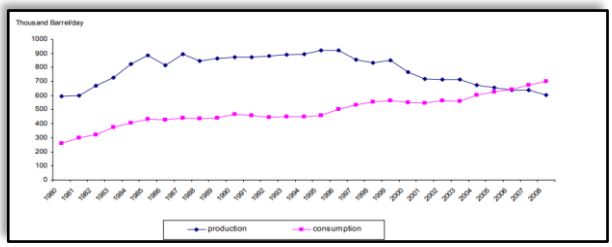
Linking between science and commerce: Egypt decided to make an organization to link science and commerce to encourage investment in scientific research, this organization is called The Research, Development, and Innovation also supports the development of ideas from drawing board to commercial products, as well as increasing cooperation between researchers and those in industry.

Making New Research Facilities: In 1991 the government of Egypt located land and money for constructing the first Egyptian Science Park on the northwest coast of Egypt to carry the name of City for Scientific Research and Technology Applications (SRTACity) aiming to Develop centers of scientific excellence, Develop Central Laboratories Core Facilities, Cooperate with different national and international institutes and organizations in the various areas of technology.

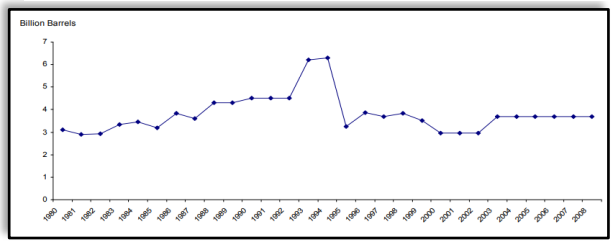
Also, the Ministry of Scientific Research has shown a lot of other factors that help in the improvement of the scientific and technological environment by increasing the salaries of researchers at government universities and research centers, employing extra graduates as researchers, and developing 25 centers of excellence in different fields

Problem to be solved

The huge usage of non-renewable energy



Graph 5



Graph 6

The non-renewable sources of energy are one of the most important reasons for pollution in Egypt as we use non-renewable sources of energy in about 90% of total energy consumption as the production of oil has increased since 1980 and reached its peak in 1996 **as shown in graph (5)**, and there is also the natural gas as it considered one of the most rapidly growing sectors in Egypt. Egypt's proven reserves have sharply increased over the last decade to reach 58,500 billion cubic feet in 2008, compared to 20,356 billion cubic feet in 1997, and less than 3,000 billion cubic feet in 1980 **as shown in graph (6)**. The effect of both sources is extensive if we looked at the oil, we would find that just 1 liter of oil can contaminate 1 million liters of water. Oil pollution can have a devastating effect on the water environment, it spreads over the surface in a thin layer that stops oxygen from getting to the plants and animals that live in the water. Oil pollution: harms animals and insects, prevents photosynthesis in plants, and disrupts the food chain. There are also many impacts on humans as the oil spilt spreads near a building it can form oil vapors which can lead to make the building unsuitable for living until expensive restoration work is completed, or in extreme circumstances the building may need to be demolished. On the other hand, natural gas emits 50 to 60 percent less carbon dioxide (CO2) than regular oil

or coal-fired power plants. It also emits greenhouse gases with a lower life cycle into the atmosphere. However, combustion also releases methane and lowers air quality so we can say that the usage of natural gas is better than oil but it still harms the environment. we can say that the problem that Egypt faces is the lack of renewable sources of energy which make it forces it to use the sources that pollute the environment.

The impact in Egypt if the problem is solved:

1- Egypt would reduce emissions of carbon dioxide by 37% in 2030
2- Air quality would be enhanced and that would decrease the percentage of deaths due to polluted air.
3- The decrease in the usage of non-renewable energy would make Egypt avoid the fluctuations in global oil prices.
4- When we decrease our use of non-renewable energy will provide more reliable and affordable energy access to rural and underserved communities.
5- Improving air quality would eliminate multiple diseases like respiratory diseases.

The impact in Egypt if the problem wasn't solved:

1- The carbon emission will increase by 20 % in the next ten years.
2- The air pollution will increase by approximately 15% in the urban areas.
3- Increase in the cost of electricity due to using of un-renewable energy as it needs high cost to extract.
4- The geopolitical tension will have a significant effect on Egypt as it depends on the imports of non-renewable resources.

Research

Energy sources are many in our world. There are renewable energy sources and non-renewable energy sources. Each one of them has different properties. There are many advantages and disadvantages to these sources and the way they produce energy or electricity.

What is the electricity?

a fundamental form of energy observable in positive and negative forms that occur naturally (as in lightning) or are produced (as in a generator) and that is expressed in terms of the movement and interaction of electrons.

What is energy?

We can define energy as the ability to do work as scientists define it. People have learned how to change energy from one form to another and then use it to do work so, modern civilization is possible because People use energy for a variety of things, such as to walk and bicycle, move cars along roads and boats through water, cook food on stoves, make ice in freezers, light our homes and offices, manufacture products, and send astronauts into space. Energy has a lot of forms like:

- Heat
- Light
- Motion
- Electrical
- Chemical
- Gravitational

So, what are the types of energy?

1-Renewable energy:

Renewable energy is the energy that is produced from natural sources that are replenished at a higher rate than they are consumed. The types of renewable energy are:

1. Solar energy.
2. Wind energy.
3. Geothermal energy.
4. Hydropower energy.
5. Bioenergy.
6. Ocean energy.

1)Solar energy:

Figure 8 solar panels.

Solar energy is one of the most effective types of renewable energy which depends on sunlight. It works with solar panels that are made up of photovoltaic cells **as shown in figure 8.** These cells work on absorbing the sunlight and transforming it into electricity.

2)Wind energy:

Figure 9 Zafarana wind farm.

Wind energy works on the kinetic energy of wind. The best locations have a large amount of wind speed. Wind farms are increasing all over the world. One of the most known wind farms in Egypt is (the Zafarana wind farm) which is shown in **Figure 9**. The blades' length and the turbine's height play a big role in the amount of electricity it produces.

3)Geothermal energy:

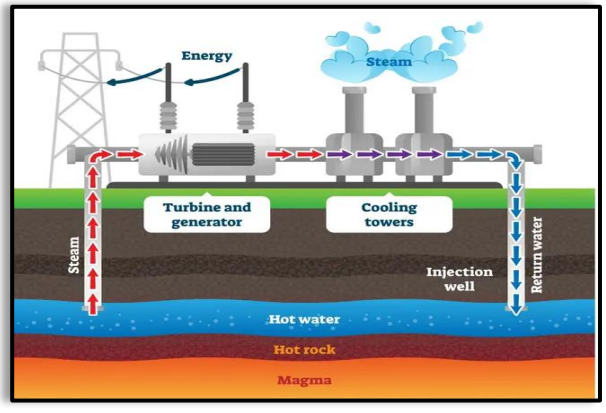


Figure 10 How Geothermal energy works.

Geothermal energy depends on underground heat. This energy works by absorbing the steam of the steam of the heated water in the subsurface of Earth and

transforming it into electricity without harming any kind of wildlife or harming the natural environment. This process works by cooling towers that get the steam out and let the water in the subsurface again. This happens after the turbines produce the electricity.

Figure 11 Aswan high dam in Egypt.

4)Hydropower energy:

Hydropower energy depends on the flowing water of the rivers. The base for generating electricity was created by the Greeks to run wheels. This idea has developed into turbines, and these turbines are added to the dams. The dam works on storing water and produces energy from the turbines. The turbines transform the flowing water's kinetic energy into electricity. One of the most known dams is the Aswan High Dam in Egypt **which is shown in Figure 11.**

5)Bioenergy:

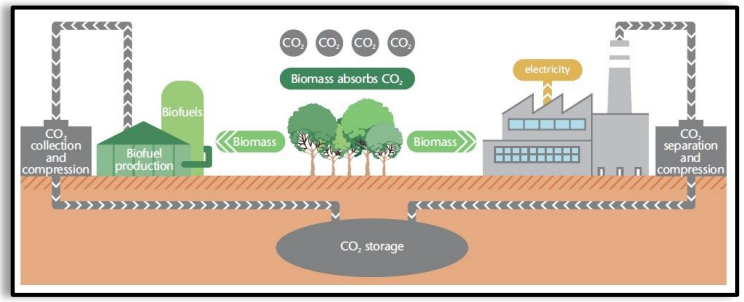


Figure 12 Bioenergy producing cycle.

Bioenergy comes from organic sources like plants and waste. It is made by burning wood, making ethanol from crops, or turning waste into biogas. It is sustainable because plants and waste can be continuously produced. It is a greener option than fossil fuels and helps reduce greenhouse gas emissions. Challenges include competition with food production and sustainable sourcing.

6)Ocean energy:

Ocean energy is the most varied renewable energy. There are 4 types of it and they are:

1. Wave energy
2. Tidal energy
3. Salinity gradient energy
4. Ocean thermal energy

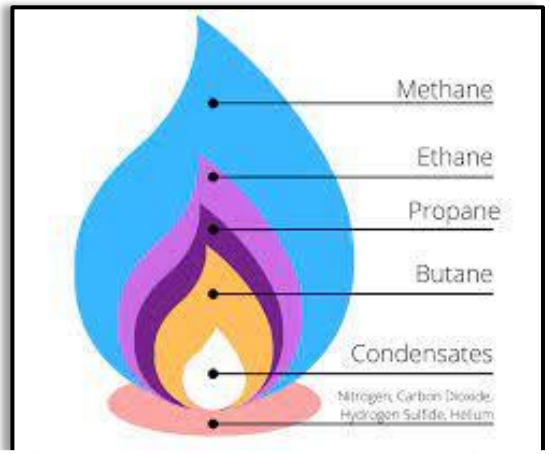
Figure 13 The projects that produce energy from all types of ocean energy.

Wave and tidal energy work on transforming the kinetic energy of their movement into electricity. The Salinity gradient energy transforms the chemical reaction created by some devices that add some chemicals to the saltwater of the ocean. Ocean thermal energy helps the sea to be cooler which helps the Oceanic wildlife and produce electricity from the high temperature of the sea.

2-Non-renewable energy:

Non-renewable energy comes from limited sources most of it comes from underground. Most of these sources have a big role in polluting the environment and causing climate change. These sources are limited which means that they will end one day even if they are a lot nowadays they will end. Non-renewable energy sources are:

1. Natural gas
2. Petroleum
3. Coal



1)Natural gas:

Natural gas is the least polluted source for the environment and the most

source of energy that Egypt has. It comes from fossil fuels. Some changes happened to the remains of the plants and animals from a long time ago, these remains had been buried before these changes, and these remains transported into 3 things (Natural gas, Petroleum, Coal). That is where the natural gas comes from. This source is made up of some polluted gases like methane, which makes it polluted. Natural gas is mostly used for heating or generating electricity.

2)Petroleum:

Petroleum means rock oil in Latin. It is a fossil fuel that is made mostly of hydrocarbon molecules. It is a liquid and the vapor of it is natural gas. The world uses about 4.2 trillion gallons a day of petroleum, which is a huge amount of petroleum used daily. Petroleum uses are a lot most industries depend on it because of machines, cars, and many other things. The hydrocarbon molecules of petroleum harm the environment which makes it a disadvantage even if it is the most important and needed non-renewable energy source.

Figure 15 Petroleum extraction.

3)Coal:

Coal is a very old energy source; it was used in the past 3,000 years ago for heating food. It is made up mostly of carbon and hydrocarbon and it took millions of years to be made underground. The most use of coal is burning it to heat and cook food **as shown in Figure 16**. There is a huge amount of carbon

Figure 16 Burning coal.

dioxide in the atmosphere because of burning coal. Coal can be used to generate electricity. It has many other uses for industry such as soap.

We can find that renewable energy sources are much better than non-renewable energy sources.

kinetic energy

What is the kinetic energy?

It's electricity that is generated because an object has motion.

When you act on an object you do work. After that the object will accelerate after the energy is transferred to the object and will have a constant speed, then that transferred we called kinetic energy.

Kinetic energy can transfer from one object to another and transfer to another kind of energy for example there are 2 cars one of them has a constant speed and the other is at rest, so the first car has crushed the second car, Following the collision, some of the initial kinetic energy of the first car has been transferred into the second car or transformed to some other form of energy.

So how can we calculate kinetic energy?

To find the kinetic energy we follow the reasoning outlined above then by finding the work done, W, by a force, F in a simple example. Consider a box of mass m pushed through a distance d along a surface by a force parallel to that surface. $W = F.d$

$$W = m \cdot d \cdot \frac{v_f^2 - v_i^2}{2d}$$
$$= m \cdot \frac{v_f^2 - v_i^2}{2}$$
$$= \frac{1}{2} \cdot m \cdot v_f^2 - \frac{1}{2} \cdot m \cdot v_i^2$$

Figure 17 how we get the equation.

= m. a . d

So kinetic energy = ½ m v^2

Which is m= mass, v= velocity

Amperes, Volts, and Watts

What Are Amps, Volts, and Watts?

Wondering what the difference between amps and volts is? Voltage, amperage, and wattage are all related.

Amperes: *commonly we say amps, when we measure electricity, we are essentially calculating the electric current, that's because it tells us how many electrons are moving through a certain point in each timeframe. To help understand this, you can think of amps as the amount of water flowing through a hose. Just like how a higher volume of water means a stronger current, more electrons passing through a point means higher amps.*

Volts: *what is the thing that makes amps flow? Voltage.*
In staying with the cultivate hose similarity, voltage is comparable to the water weight in the hose. The weight, or drive, is what causes the water to stream. Volts are a degree of how much drive each electron is beneath, which is called "potential." The potential is what causes power to stream. The distinction between volts and amps is that amps degree the volume of
electrons streaming whereas volts degree the weight causing them to stream.

Watts: Amps and volts combine to create watts, a measurement of the amount of energy being released. In the case of the garden hose, this would be the amount of water flowing. The higher the wattage, which we now know is the combination of electrical potential and flow, the more power and output we'll see. For example, the more wattage a microwave has to offer, the faster it will cook your food. So, to calculate them we use the equations:

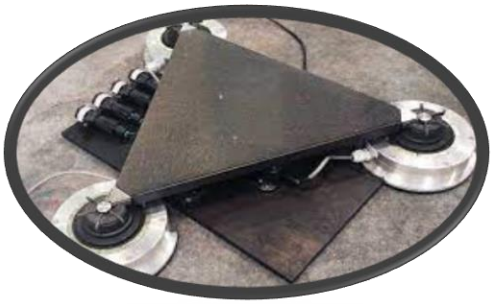
- Watts = Amps x Volts
- Amps = Watts / Volts
- Volts = Watts / Amps

Prior solutions

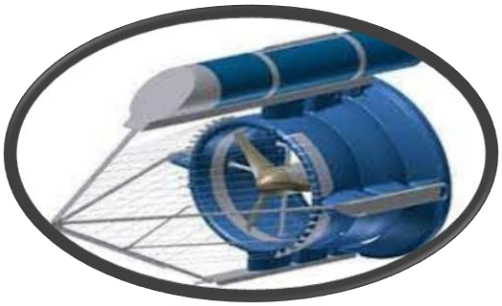
After defining the problem, its causes, its effect in many fields, and its relation to Egypt's grand challenges, it is necessary to see the scientists' efforts to solve it, and the prior tries to find solutions to it.

This can give a background for generating another solution and avoiding the mistakes that the scientists made, and also it increases the knowledge about the problem, and to see the latest technologies that were made to solve the problem and trying to improve them.

For that aspect, three prior solutions for that problem were chosen to be discussed in detail by seeing their mechanism of working, its results, its advantages and disadvantages.



Kinetic energy harvesting system



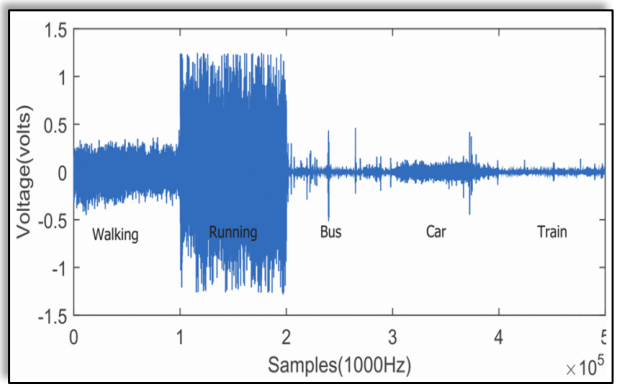
Hydrokinetic Turbines in Water Infrastructure

Steam engine to generate electricity

Wind Turbines

Kinetic energy harvesting system

One of the solutions that could solve the same problem that we want to solve is (the Kinetic energy harvesting system). The kinetic energy harvesting system is the process that produces electricity from human motion, vehicle movement, wind or waves, vibration energy, etc. The reason for making this project is to detect the vibration of transport type and know the voltage that it produces. The researchers were able to realize 98.84 percent exactness in deciding whet her the client was walking/running or in a motorized vehicle. The overall accuracy of classification between motorized vehicles (bus, car, train) was over 85 percent **as shown in graph (7)**. It is made of a piezoelectric material; it generates an AC voltage proportional to the applied stress. This idea is applied in The United Kingdom and other countries like the USA and Brazil in the sidewalks and urban congestion places, so it gets the energy from people's steps. It is a project of an electric floor installed in tiles that has a sensor that determines the kinetic energy of footsteps and converts this energy to electricity **as shown in Figure (18)**. All this is made with piezoelectric material.



Graph 7 (The voltage generated by the wearable records distinctive differences between the user's transportation modes.)

Figure 18 (a piece of floor installed in sidewalks.)

Because nothing is perfect, in any project there are advantages and disadvantages points. Also, this project has strengths and weaknesses.

The advantages:

The advantages of this project are:

1) It is a renewable energy source: it generates electricity from human footsteps which is a green source of energy.
2) It has a modular design and scalability which means that it can fit in many different areas.
3) It can have a full data collection as shown in (Graph 7).

The disadvantages:

The disadvantages of this project are:

1) The amount of energy that it produces is less than the other renewable energy sources.
2) The initial cost of it is very high even if it doesn't have to be maintained a lot.
3) Components such as generators and energy storage systems add bulk and weight to the overall system, which can be a limiting factor in certain applications, particularly those requiring compact or lightweight designs.

Hydrokinetic Turbines in Water Infrastructure

Hydrokinetic Turbines in water infrastructure are devices to generate electricity by capturing the kinetic energy present in flowing water and then converting the kinetic energy to electric power.

These devices can be found in rivers, canals, or tidal currents.

hydrokinetic turbines work directly in the water without impeding the natural flow, unlike hydropower systems that are often used in dams.

The hydrokinetic turbines generate renewable energy that's because These turbines are particularly well-suited for locations with consistent water currents.

How Hydrokinetic Turbines Work:

Figure 19

Hydrokinetic turbines harness the kinetic energy of flowing water to generate electricity. The basic principle behind their operation is like that of wind turbines, but instead of wind, they capture the energy of moving water

after that the propeller rotor blades are center pivoted and oriented to intercept the water flow When water flows over the rotating blades, it results in the rotation of the blades and the attached shaft. This rotational motion represents the conversion of kinetic energy from moving water into mechanical energy in the form of rotation.

Then a generator converts the mechanical energy from the rotating blades into electrical energy

The generated electrical energy is then transmitted via cables to an onshore facility or integrated directly into an underwater network. It can be used to power local communities or industries or fed into the larger electrical grid.

Advantages:

1-Reduced Environmental Impact:
Hydrokinetic turbines have a lower environmental impact compared to traditional hydropower, as they do not require the construction of dams that can alter ecosystems and fish migration patterns.

2-Generating constant electricity
When water is moving, hydrokinetic turbines can generate power continuously since they offer a reliable energy supply.

3-Integration with Existing Infrastructure:
There is no need for major construction because hydrokinetic turbines

may be placed into already-existing water infrastructure, like piers or bridges.

But there are some **disadvantages** to this project like:

1-Environmental Impact:
Hydrokinetic turbines can have an impact on aquatic ecosystems, Hydrokinetic turbines have a rotating blade that can impact Fish and other marine potentially leading to injuries or disruption of migration patterns.

2- Navigational Safety:
Hydrokinetic turbines can have an impact on vessels, especially on smaller vessels. Proper signage and navigation guidelines are necessary.

3- Limited Suitable Locations:
Hydrokinetic turbines are put on water bodies with consistent and predictable flow patterns that make them more effective.

Steam engines to generate electricity

History:

Steam engines were one of the most used machines all over the world in the 18th, 19th, and 20th centuries, their main purpose was to convert thermal energy into mechanical energy that could be used in many applications such as running steam trains, and they are also a great choice for generating electric power by converting the mechanical energy produced by them using electric generator.

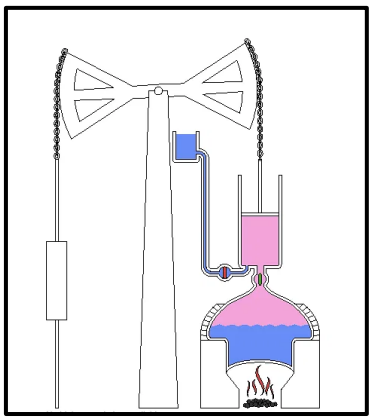


Figure 20
(Newcomen first steam engine diagram)

The use of steam engines started to spread widely by the beginning of the Industrial Revolution in the 18th century. The first steam engine was made in England by the scientist

Thomas Newcomen in 1712, it was made to carry the water coming out from deep coal mines the obstacles coal extracting, it wasn't that efficient because it consumed too much coal to heat the water, and it wasn't developed very well as it worked by the atmospheric pressure to return the moving piston.

Figure 21 (a developed design for steam engines)

There were many developments to the steam engines all over the 18th and 19th centuries to improve their efficiency and output energy, such as the development of James Watt in 1769 and the other in 1778 by Watt also, William McNaught in 1845, and Charles Parsons in 1884.

By 1800, Britain boasted over 2500 steam engines, which were widely used in many fields like mines, cotton mills, and manufacturing factories, steam engines were spreading widely with the passage of the Industrial Revolution, and many applications were made to the steam engines, like steam trains, steamships, steam cars, etc.… So, by 1907 there were 9.5 million steam-powered machines.

<u>Mechanism of working</u>:

There are many designs for steam engines, each one having its own usage, the shown design **in Figure (19)** is the basic and most known design for steam engines.

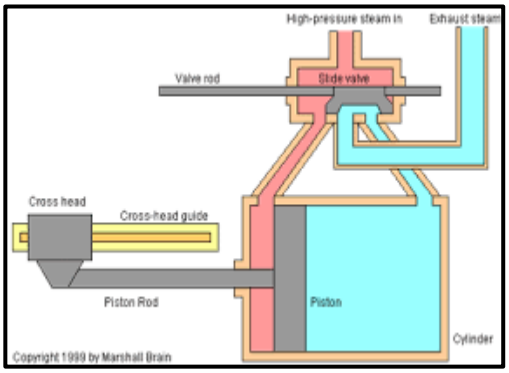


Figure 22

The first step in this machine to work is to heat a fluid until it evaporates, this gas is usually water because its volume in the gas state is 1500 times more voluminous than it is in the liquid state, heating and evaporating water creates a very high-pressure steam.

The second step is to drive this high-pressure steam into pipes to reach a cylinder with a piston in it, the steam will be on one side of

the cylinder and the piston separates it from the other side, this will create a pressure difference between the two sides of the cylinder making the piston to be pushed to the low-pressure side, this movement will be transmitted from the piston to a rotating wheel by a rod.

The last step is to return the piston to its first place to repeat this action, this can be done by changing the pressure difference between the two sides of the cylinder to make the low-pressure side greater in pressure than the other side. A valve takes a role in this, a valve connected to the rotating wheel changes the path of the steam, to make the steam go to the low-pressure side to make it higher in pressure, and opens another path to get the steam in the other side out to make it lower in pressure. Rotating the wheel will move the valve and change the pressure difference between the two sides of the cylinder, and repeating this will cause the piston to go forward and backward creating mechanical energy.

This can work as an engine to run many machines. But to generate electricity from this, an electric generator that changes the mechanical energy into electricity is needed to change the mechanical energy in the rotating wheel into electricity.

Advantages:

- High efficiency: The latest designs of steam turbines have great efficiency and output and are able to generate large amounts of electricity.

- Reliable: Steam engines not like many machines are considered simple machines that are made of simple parts and not difficult to build, and also can have long lifespans with proper maintenance.

- Fuel flexibility: steam turbines can change the thermal energy in most types of fuels into mechanical energy.

Disadvantages:

- Cost: to build a steam engine, you need hard materials that can resist high pressure and high temperatures, which often cost a lot.

- Water dependence: steam engines can't work without large amounts of water for steam and cooling purposes, so to run large electricity-generating farms you need a large source of water, which may not be available in some regions.

- Environmental impacts: the thermal energy in steam turbines usually comes from burning fossil fuels, which has bad impacts on the environment and can lead to disasters.

Wind turbines

History:

The use of wind to generate energy all over the world isn't a new idea, it has been used for ages in different applications. The ancient Egyptians used the wind to run boats in the Nile River 5000 years BC, and about 200 years BC, a water pump was invented to use the wind as the source of energy, and this technology was widely used in the 11th century by the farmers in the middle east, and it continued to be developed by the Europeans, then the first wind-electric generator was built by the end of 19th century.

Figure 23 (old wind turbine in Europe)

This technology was widely used all over the world on farms, but its usage was decreasing by the 20th century because of using other types of energy mostly fossil fuels. By the end of the century, the world realized that the planet is facing horrible problems, global warming and melting of poles' ice, and the main cause of these problems is the huge usage of fossil fuels and the carbon dioxide emissions in the atmosphere, so the world changed its way for using energy and started depending on renewable sources, this made the use of wind turbines increase all over the world because it is a green renewable source, and also as it was already tried in the past and was effective in some regions.

Figure 24 (Zafarana wind farm in Egypt)

With the increase in the usage of wind turbines, the US government installed thousands of wind turbines in California, and it helped in providing research for reducing the cost of building these turbines, the energy produced from wind in the US was about 1% of the total produced energy in 1990 and increased to 10.2% in 2022. In China, there was a huge increase in wind energy and now it is the biggest producer of wind energy in the world. In 2021, at least 128 countries generated about 1,808 billion kWh of wind electricity.

In Egypt, two main wind energy farms were built to increase the energy from wind turbines, the first was in 2001, the Zafarana wind farm, it is the biggest in Egypt and includes 700 wind turbines with a total capacity of 745 MW, another one is the Jabal Al-Zayt wind farm which includes 120 wind turbine and has a capacity about 240 MW.

Wind turbines aren't a new technology for the world, but they have become very necessary to use in the 21st century, and many countries are trying to increase their energy production from them.

Mechanism of working.

The wind movements are caused mainly because of three main events:

1. The sun unevenly heating the atmosphere
2. Irregularities of the earth's surface
3. The rotation of the earth.

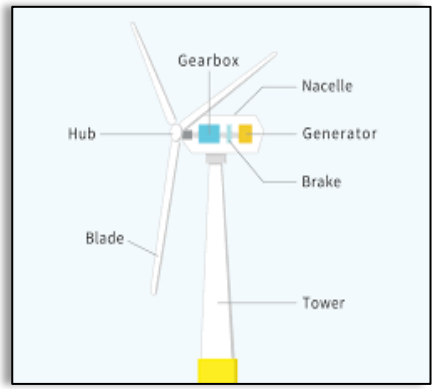


Figure 25 (shows a simple wind turbine design)

Wind energy is considered a form of solar energy. The mechanism of generating energy from wind currents is very simple. first of all, choosing the place where to build the wind farm, needs to be a place with high-speed wind currents running through it most of the year. The wind turbine itself is made of blades which collect the mechanical energy from the wind and convert it into a rotational motion around a rotor, this rotor is connected to a generator to generate electricity.

Advantages:

- Clean energy: Wind turbines generate electricity without producing greenhouse gasses or other pollutants, making them a sustainable choice for reducing reliance on fossil fuels.
- Renewable resource: Wind is a constantly replenished resource, unlike finite fossil fuels.
- Cost-effective: Wind energy has become a relatively low-cost way to generate electricity, especially considering the fuel source (wind) is free.
- Low maintenance: Once built, wind turbines require minimal maintenance, keeping operational costs low.
- Job creation: The wind industry creates jobs in the manufacturing, installation, and maintenance of wind turbines.

Disadvantages:

- Unreliable: Wind isn't always blowing, so wind energy is not a consistent source of power. This can be addressed by integrating wind farms with other energy sources or using battery storage systems.
- Impact on wildlife: Birds and bats can be injured or killed by colliding with turbine blades. Efforts are underway to minimize this impact through careful placement of turbines and deterrents.
- Land use: Wind farms require a significant amount of land, which can compete with other land uses like agriculture or wildlife habitat.

Solution and Design requirements

We Have Decided To choose some requirements to ensure the accuracy of the project in producing electricity from school and student activities without affecting those activities those requirements are:

Non-impediment: The prototype that we will select mustn't tackle or affect the student activity and so it will be a small and non-noticeable solution so we have to reduce the surface area taken by the prototype

Environmentally friendly: the solution must be environmentally friendly as it doesn't pollute the surroundings and doesn't depend on sources of energy that pollute the environment like fossil fuel and relies on renewable and mechanical sources of energy that will transfer into electrical energy.

Stand high temperatures: The prototype must be able to stand high temperatures without any bending or the inner components being melted down by the effect of temperature as the prototype will deal with student activity that faces high temperature

User friendly: The prototype has to be user-friendly as it should be easy to use and doesn't require an expert to launch it, also, it must be accessible and made of materials that can be found in Egypt and be as cheap as possible. In addition, it must have continuous improvement. Furthermore, the prototype must be flexible and can be made of different materials

Fast in producing energy: the prototype should be fast in producing electricity with an equal amount of energy in equal periods of time as it has to store an amount of energy at the end of the student activity that maybe doesn't take a lot of time.

Design requirements:

- Based on one item of the school environment or student activity.
- Produce at least 150 joules (equal 0.5 watts) in at most 5 minutes.
- Store the energy in any electric storage device to be able to use at any time.
- Show the electric energy in a useful application that can access the amount of saved power.
- Using waste materials.

Selection of solution

The problem of pollution can be represented as a mixture of several smaller problems and some of them can be shared in the problem of the population more than others. The problem that shares the largest percentage of the pollution problem is the usage of non-renewable energy such as fossil fuels. even if humans believed that pollution would lead us to a serious problem that we won't be able to fix in the future we can't stop using it. Due to that humanity went to another solution which is increasing our usage of renewable energy but the problem is that renewable energy sources are limited or expensive and the generating operators sometimes need advanced technology. Those are the reasons that limit our usage of renewable energy in the wide-scale and various fields. After demonstrating the problems that face most of the resources of renewable energy, we chose our solution which is the Stirling engine. Stirling engine's scientific base was transferring the heat energy into mechanical energy depending on Hermann von Helmholtz's law of conservation

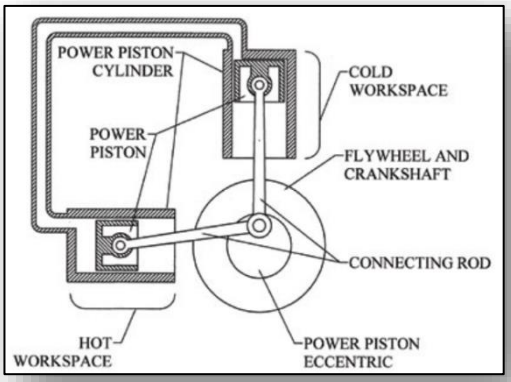


Figure 25

of energy. To understand our solution, you first had to know what the parts the Stirling engine" as shown in fig.1" consists of, first, we had a cylinder part that contains the fluid that gets heated and cooled to be expanded and compressed then we had the piston that moves inside the cylinder and we had the flywheel and the crank craft which are connected to the piston we had the dynamo that is connected to the flywheel. The mechanism of that process is based on several steps as the following:

1- Heating part of the cylinder with any external source of heat such as solar heat, or flam.
2- The fluid inside the cylinder gets heated which makes it expanded
3- When the fluid gets expanded it moves the piston forward which also moves the crank craft and the flywheel
4- The fluid gets cooled by the cooler which can be metal or another fluid like water
5- After cooling the fluid, it gets compressed again which makes the piston move backward and do the same thing for the flywheel and the crank craft
6- The cycle of expansion and compressing repeated fast and continually which led to generating electricity by moving the dynamo connected to the flywheel

We inspired our project after searching and looking through prior solutions that people supposed before us as a solution to our same problem which gave us an idea about our last version of the solution as shown in the following text.

The Steam Engine:

As we explained in the last chapter the mechanism of the steam engine(as shown in Fig. 26) helped us in our project as

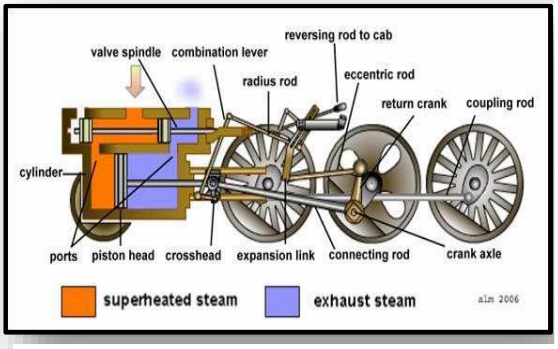


Figure 26

both depend on increasing the volume of the fluid by heating “In the steam engine the fluid is the water but in Stirling engine, it can be any fluid can expand and compressed by heat” then when the fluid cools it decrease its volume which responsible for the movement of the piston which connected to the tank of the fluid and that lead to transforming the thermal energy that gained from an external source in both engines to mechanical that can be used in different fields.

The Wind Turbines:

In wind turbines, it receives the mechanical energy which is made by the wind which moves the blades and converts it into electric energy. The device responsible for generating electricity in the wind turbines is called a dynamo which was helpful in our process of designing the solution as the dynamo uses the external mechanical (as shown in fig.27) energy in the rotating of wires and makes a magnetic field which helps generate electricity.

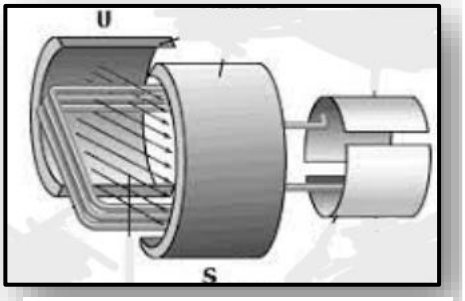


Figure 27

As mentioned before energy can neither be created nor destroyed; rather, it transforms from one form to another. So, when we want to generate electricity, we have to find a source of energy that we can transform from its original state to the electric state. In our challenge, the source of the energy had to be related to the student activity without interrupting them so we decided to use the unused thermal energy generated by the ovens of the kitchens of the residential restaurant.

We measured the products of the solution which supposed to generate:

- The rate of flow of electric charge: x ampere
- The electrical potential difference: x voltage
- The work can be done: ampere x voltage
- The amount of energy transferred: watts x time

Selection of Prototype

In most of the ideas the prototype is made of a small scale and in real life, they apply a large-scale prototype but, in our prototype, we use the small scale as our project had an inverse relation with the efficiency.

Our prototype had different parts with different dimensions (shown in Fig. 1) they are shown in detail in the following:

- **The external piston:**

Diameter: 7 cm

The height from the bottom: 12.5 cm

The range height of movement (measured from the bottom): from 27 cm to 29 cm

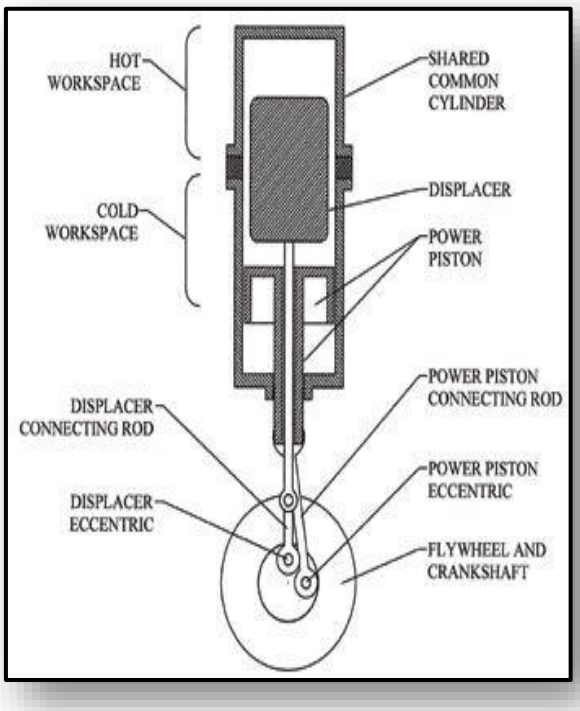


Figure 28

- **The internal piston:**

Diameter: 5.5 cm

Thickness: 3.7 cm

- **The cooling tank:**

Occupied area with water: 406.7 cm^2

The height from the bottom: x cm

- **The internal tank:**

Occupied area: 95 cm^2

- **The flywheel:**

Diameter: 11.7 cm

Thickness: 0.5 cm

- **The crank-craft:**

The length of the internal piston arm: 18 cm

The length of the external piston arm: 14.5 cm

- **The dynamo produces DC that can be stored in a battery to be used in other applications**

The mechanism of generating electricity:

1- Heating the fluid inside the internal tank.

2- The fluid expanded and raised the internal piston up.

3- The external tank cools down the fluid with the water.

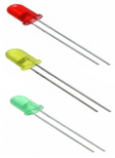
4- The fluid is compressed and generates linear mechanical energy by moving the crank-craft.

5- The crank-craft transfers the linear mechanical energy to the flywheel which is responsible for changing the linear to rotational mechanical energy.

6- The dynamo which is connected to the flywheel receives the energy transferring its electricity.

Materials and Methods

	Usage	Cost	Source of purchase	Quantity	picture
Spray head.	Used in the structure of the external piston	----------	recycle	1spary with 53mm diameter.	
Spray head with 63mm diameter.	Used in the structure of the external piston	----------	recycle	1spary with 63mm diameter.	
Drink can.	Used in building structure of engine	----------	recycle	1can	
Food can.	Used in making both cooling and heating tank	----------	Recycle	2 cans	
Epoxy glue.	Sticking the materials together to shape the project	15L.E	natural	1Epoxy glue	
Wiretaps.	To allow the air to pass through the internal piston	-------	recycle	0.5 meter	

Ballon.	Prevent the air from leaving the external piston	-------	recycle	1 ballon	
Aluminum skewer.	Used in making the arms of pistons, flywheels, and crank craft	-------	recycle	4 skewers	
Bottle cap	Used in making the external piston	-------	recycle	1Bottle cap with 40mm diameter	
Dynamo DC.	Transforming the mechanical energy to electric energy	-------	Electric shop	dynamo	
DVD	Making the flywheel structure	-------	recycle	4 DVD	
Wheel tire	Fixing the ballon to prevent the leakage of the air	-------	recycle	1 tire	
Wheel string		-------	recycle	3	
battery	Save energy that is produced	-------	recycle	1 battery	
Led Lamp	Use electric power in useful	5 L.E	Electric shop	1 lamp	

Light connectors	connector Piston arm with crank craft	10 L.E	Electric shop	8 connectors	
Crocodile wire	Connect electricity to all the prototype	4 L.E	Electric shop	4 wires	

Methods of construction:

After searching for the materials that we will use in the prototype and preparing them to get ready to construct our prototype, there were some methods that we made to know how will we make the prototype:

1-We used the cans to do the structure of the device.

2-We used food cans to do a tank of flowed.

3-We used food cans to cool the tank.

4- We used metal wool a wire wheel on top of the can and 2 light connectors to do the first piston.

5-We used the head spray on the second piston.

6-We used the wire of the wheel and 3 light connectors to do the crank craft.

7-We used 4 CD to make the flywheel.

8-Connect the crank craft with the flywheel.

9- The top of the bottle-like gear is connected with a dynamo.

Safety procedures:

For continuing in the process of constructing the prototype, some safety procedures must be followed to avoid any unwanted thing to happen, they are shown below:

Wearing gloves: this keeps hands safe while cutting cans of dealing with sharp thing, and also can protect them from getting burned from heat sources.

Wearing googles,this keeps eyes safe while using any cutting machine and avoid any tiny particle to hit them.

Being aware while dealing with the electric current to avoid to get an electric shoch which would be harmful.

Making sure that all the wires in the prototype is perfectly isolated.

Test plan

After finishing the prototype, a test plan needs to be done to make sure that the prototype was made in good composition to suit the design requirements which are shown below:

- Based on one item of the school environment or student activity.
- Produce at least 150 joules (equal 0.5 watts) in at most 5 minutes.
- Store the energy in any electric storage device to be able to use at any time.
- Show the electric energy in a useful application that can access the amount of saved power.
- Using waste materials.

To make sure that the prototype follows these requirements, we made steps to test it.
Firstly: make sure that the solution is based on student activity.

Secondly: make sure that the dimensions of the materials used are accurate to the design, this can be done by calculating the error percentages in cutting the materials.

Third: A multimeter will be used to collect the produced voltages and amperes from the prototype, these are the most necessary data to be collected.

fourth: using these data to calculate the power of the electricity produced in watts, this can be done using the following equation:

$$\textit{Watts} = \textit{voltage} \times \textit{ampere}$$

Fifth: we calculated the amount of stored energy represented by unit joules, which can be calculated by the equation:

$$\textit{joules} = \textit{watts} \times \textit{time}$$

sixth: we will use a battery to store the energy to be able to use it at any time.

Seventh: we will use a lamp to use the electric energy in a useful application.

Data collection

Building and constructing the sterling engine required a lot of measurement and building instruments, such as:

	**Multimeter:** It was used to calculate voltage and amperes
	**Measure tape:** it was used to measure the dimensions of the materials
	**Digital tachometer:** it was used to calculate the Lap speed

After testing the device here is the result, which should Produce at least 150 joules (equal to 0.5 watts) in at most 5 minutes. We do thr see tests for more accuracy.

The positive results:

Table 1 (the AMP, V, W)

Trials	Time (second)	Potential difference (volt)	Electric current (ampere)	Power (watt)
First	**1st 300 sec**	**3.13volt**	0.172 amps	0.54w
Second	**2nd 300 sec**	**3.30volt**	0.181 amps	0.60w
Third	**3rd 300 sec**	**3.07volt**	0.210 amps	0.64w
Fourth	**4th 300 sec**	**2.94 volt**	0.195 amps	0.57w
Average	**300 sec**	**3.11 volt**	0.189 amps	0.5875w

Watt was calculated using the equation W=V.A, then we need to convert the watt to joule, the equation that d this is=W.T

Table 2 (the amount of energy produced

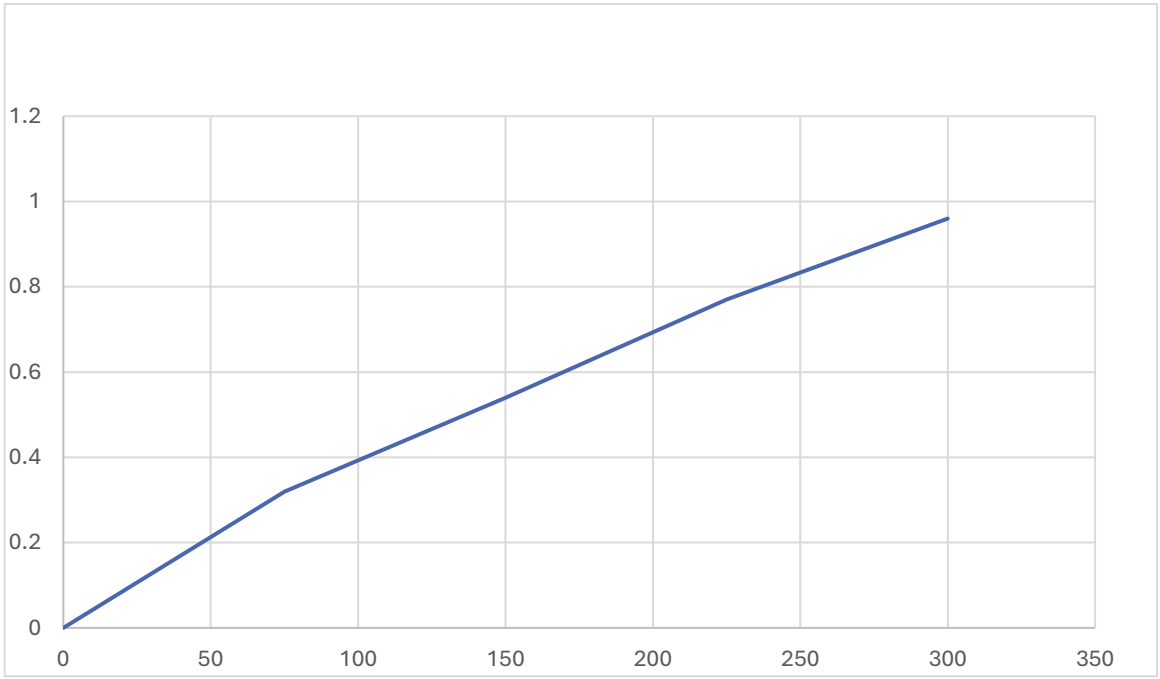
Trials	Time (seconds)	Energy (Joules)
First	300 seconds	162 Joules
Second	300 seconds	180Joules
Third	300 seconds	192Joules
Fourth	300 seconds	171Joules
Average	----------	176.25Joules

As shown in the last table we produce more than 150 joules in 5 minutes.

We measured the lap speed after calculating the voltage and ampere with a multimeter.

	Speed
First	819 RPM
second	761 RPM
third	787 RPM
Fourth	780 RPM
Average	786.75 RPM

We used in the prototype a dynmo dc that take an input =12 volts and take out 3 volts ,so the efficncy that calculate with law Output ÷ Input *100. so, the efficiency of the device =3/12*100=25%



Analysis and Discussion

The solution “Converting thermal and mechanical energy into electricity using Stirling engine” tries to solve two main grand challenges, which are improving the usage of alternative energy and improving the scientific and technological environment for all. They are the main challenges that face Egypt and the whole world in general.

The solution tries to solve the problem which is the huge usage of non-renewable energy as we use non-renewable sources of energy in about 90% of total energy consumption as the production of oil has increased since 1980 and reached its peak in 1996.

The idea depends on transferring heat energy into mechanical energy depending on Hermann von Helmholtz's law of conservation of energy. A cylinder part that contains the fluid that gets heated and cooled to be expanded and compressed then we had the piston that moves inside the cylinder, and we had the flywheel and the crank craft which are connected to the piston we had the dynamo that is connected to the flywheel. In most of the ideas the prototype is made of a small scale and in real life, they apply a large-scale prototype but, in our prototype, we use the small scale as our project had an inverse relation with the efficiency. To achieve one of the most important design requirements which is all of the materials are recycled or natural. The materials that we used were DVDs, drink cans, food cans, and other materials that have a high heat resistance.

After choosing the solution the idea must be constructed and tested. The test plan depended on making sure that the design requirements were achieved. One of the most important steps in the test plan was to calculate the output voltage.

After obtaining the results, an analysis was required to measure how much the goal was reached and how close were the design requirements achieved. The test plan results of the first test plan have achieved the design requirements as it produced 279 Joules in 5 minutes as shown in the results. This has been calculated by the rule.

watt=Joules/time

In addition, the output has been measured by a multimeter to estimate watts by the rule.

watt=voltage*ampere

Also, the lap speed was measured with a digital tachometer and the first result was 819 RPM. With that, the design requirements have been achieved. The second test plan results are 288 Joules and 671 RPM. The third test plan results are 327 Joules which is the best of all the results with a lap speed of 787 RPM. The Fourth test plan results are 276 Joules and After all of that, the average output has been calculated for the Joules which is 292.5 Joules. With these results, the design requirement which is the prototype must produce at least 150 Jules (0.5 watts) in at most 5 minutes is achieved. To produce all of that the behavior and the prototype work. The process starts with heating the fluid inside the internal tank. After that, the fluid expanded and raised the internal piston. The external tank cools down the fluid with the water. Then the fluid is compressed and generates linear mechanical energy by moving the crank-craft. The crank-craft transfers the linear mechanical energy to the flywheel which is responsible for changing the linear to rotational mechanical energy. The dynamo which is connected to the flywheel receives the energy transferring its electricity. Other requirements have been achieved such as that all of the materials are recycled or natural materials. Furthermore, the cost is very low as we use cheap and recycled materials. During the test plan, it was found that no part of the prototype was harmed which achieved the solution requirements (Durability, Sustainability, Quality, Safety, and Cost).

Recommendations

“Nothing is perfect”, this is the main idea in every project. Some things could be applied, and others can develop or upgrade the prototype or even the real application.
These recommendations are referred into some points, and they are:

1: Develop the real application by making it with materials that have high heat resistance and sustainability, as well as good thermal conductivity.

2: Minimize resistance within the engine to enhance its efficiency, ensuring proper lubrication and facilitating fluid movement of its components. Yet, maintain a careful balance with the necessity of generating ample power to propel the engine with vigor.

3: Develop the prototype and the real application by adding a high healing point fluid in the heating tank.

4: Apply the cooling tank with a material that can help the fluid get cooler faster.

5: Applying safety precautions to avoid any accidents because of the high heat.

6: Focus on improving the thermal efficiency of the engine. Experiment with different insulation materials, and regenerative cooling techniques to minimize heat loss and maximize energy conversion.

During our project through the first semester, we faced challenges that made us stronger learned new skills, and connected with each member of the group we are grateful for, these skills are:

1: We learned a lot about electricity and its rules, getting a piece of knowledge in a new employment.

2: Having more skills in connecting the LOs we study with the project, especially physics and chemistry.

3: Studying all types of renewable and wasted energy.

4: For the second semester, we learned how to find a new idea and how to apply it, connecting it with students' activities.

Learning outcomes

In our project, we have made use of some learning outcomes from our curriculum in different subjects

Earth Science (ES1.09): In this learning outcome we have learned about different sources of energy and how we will make use of it we also have learned how to differentiate between Renewable and non-Renewable energy.

Earth science (ES 1.10): In this Learning outcome we have learned how to produce electric energy from various renewable resources like solar, wind, and hydropower, furthermore we have learned how to capture heat and transform it into electric energy.

Chemistry (CH 1.09): In this Learning outcome we have learned more about the physical properties of matter and focused on some of those properties like malleability, electric conductivity and more so this helped us in choosing the materials.

Chemistry (CH 1.14): In this Learning outcome we have learned about both galvanic and electrolytic cells and how to make electric current out of chemical reactions.

Chemistry (CH 1.15): In this Learning outcome we have learned about heat and how it transfers and factors that can affect heat.

Mathematics (MH 1.08): In this Learning outcome we learned about graphs and functions like quadratic function and linear functions to represent the data in an accurate way.

Mathematics (MH 1.09): In this learning outcome we have learned about exponential and logarithmic functions and how they present growth and decay so we can use them to predict any change in results that may happen in the future.

Physics (PH 1.10): In this Learning outcome we have learned about thermal energy and temperature and factors affecting temperature and how to control it.

Physics (PH 1.11): In this Learning outcome we have learned about thermodynamics and Thermodynamic processes (isothermal – isovolumetric- isobaric- adiabatic) and the law of conversation of heat and how we can use it to predict change in heat and how it will affect our prototype.

Computer Science (CS 1.07): In this learning outcome we have learned about the variables and how we can use them to make calculations easier by only writing down the correct Equation.

Citation in APA 7th

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