# Free Energy - Solar Powered Stirling Engine

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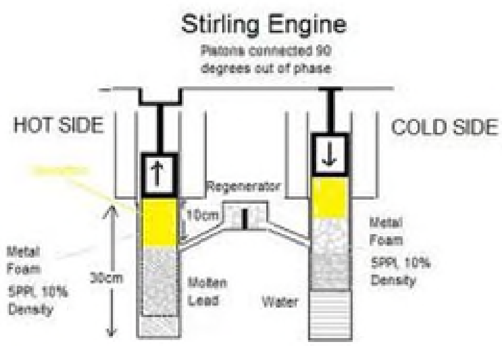


The Stirling engine is a heat engine that is vastly different from the internal-combustion engine in your car. Invented by Robert Stirling in 1816, the Stirling engine has the potential to be much more efficient than a gasoline or diesel engine. But today, Stirling engines are used only in some very specialized applications, like in submarines or auxiliary power generators for yachts, where quiet operation is important. Although there hasn’t been a successful mass-market application for the Stirling engine, some very high-power inventors are working on it.

A Stirling engine uses the **Stirling cycle**, which is unlike the cycles used in internal-combustion engines.

- The gasses used inside a Stirling engine never leave the engine. There are no exhaust valves that vent high-pressure gasses, as in a gasoline or diesel engine, and there are no explosions taking place. Because of this, Stirling engines are very quiet.
- The Stirling cycle uses an external heat source, which could be anything from gasoline to solar energy to the heat produced by decaying plants. No combustion takes place inside the cylinders of the engine.

There are hundreds of ways to put together a Stirling engine. In this article, we'll learn about the Stirling cycle and see how two different configurations of this engine work.

Video entitled *The Innovation of the Engine* https://youtu.be/KQ8J6CN5gAs

## The Stirling Cycle

The key principle of a Stirling engine is that **a fixed amount of a gas is sealed inside the engine**. The Stirling cycle involves a series of events that change the pressure of the gas inside the engine, causing it to do work.

There are several properties of gasses that are critical to the operation of Stirling engines:

- If you have a fixed amount of gas in a fixed volume of space and you raise the temperature of that gas, the pressure will increase.
- If you have a fixed amount of gas and you compress it (decrease the volume of its space), the temperature of that gas will increase.

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Let's go through each part of the Stirling cycle while looking at a simplified Stirling engine. Our simplified engine uses two cylinders. One cylinder is heated by an external heat source (such as fire), and the other is cooled by an external cooling source (such as ice). The gas chambers of the two cylinders are connected, and the pistons are connected to each other mechanically by a linkage that determines how they will move in relation to one another.

There are four parts to the Stirling cycle. The two pistons in the animation above accomplish all of the parts of the cycle:

1. Heat is added to the gas inside the heated cylinder (left), causing pressure to build. This forces the piston to move down. This is the part of the Stirling cycle that does the work.
2. The left piston moves up while the right piston moves down. This pushes the hot gas into the cooled cylinder, which quickly cools the gas to the temperature of the cooling source, lowering its pressure. This makes it easier to compress the gas in the next part of the cycle.
3. The piston in the cooled cylinder (right) starts to compress the gas. Heat generated by this compression is removed by the cooling source.
4. The right piston moves up while the left piston moves down. This forces the gas into the heated cylinder, where it quickly heats up, building pressure, at which point the cycle repeats.

The Stirling engine only makes power during the first part of the cycle. There are two main ways to increase the power output of a Stirling cycle:

- **Increase power output in stage one** - In part one of the cycle, the pressure of the heated gas pushing against the piston performs work. Increasing the pressure during this part of the cycle will increase the power output of the engine. One way of increasing the pressure is by increasing the temperature of the gas. When we take a look at a two-piston Stirling engine later in this article, we'll see how a device called a **regenerator** can improve the power output of the engine by temporarily storing heat.

- **Decrease power usage in stage three** - In part three of the cycle, the pistons perform work on the gas, using some of the power produced in part one. Lowering the pressure during this part of the cycle can decrease the power used during this stage of the cycle (effectively increasing the power output of the engine). One way to decrease the pressure is to cool the gas to a lower temperature.

This section described the ideal Stirling cycle. Actual working engines vary the cycle slightly because of the physical limitations of their design. In the next two sections, we'll take a look at a couple of different kinds of Stirling engines. The displacer-type engine is probably the easiest to understand, so we'll start there.

## Displacer-type Stirling Engine

Instead of having two pistons, a displacer-type engine has one piston and a displacer. The **displacer** serves to control when the gas chamber is heated and when it is cooled. This type of Stirling engine is sometimes used in classroom demonstrations. You can even buy a kit to build one yourself!

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In order to run, the engine above requires a **temperature difference** between the top and the bottom of the large cylinder. In this case, the difference between the temperature of your hand and the air around it is enough to run the engine.

In the figure on this page, you can see two pistons:

1. The **power piston** - This is the smaller piston at the top of the engine. It is a tightly-sealed piston that moves up as the gas inside the engine expands.
2. The **displacer** - This is the large piston in the drawing. This piston is very loose in its cylinder, so air can move easily between the heated and cooled sections of the engine as the piston moves up and down.

The displacer moves up and down to control whether the gas in the engine is being heated or cooled. There are two positions:

- When the displacer is near the top of the large cylinder, most of the gas inside the engine is heated by the heat source and it expands. Pressure builds inside the engine, forcing the power piston up.
- When the displacer is near the bottom of the large cylinder, most of the gas inside the engine cools and contracts. This causes the pressure to drop, making it easier for the power piston to move down and compress the gas.

The engine repeatedly heats and cools the gas, extracting energy from the gas's expansion and contraction.

Next, we'll take a look at a two-piston Stirling engine.

## Two-piston Stirling Engine

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In this engine, the heated cylinder is heated by an external flame. The cooled cylinder is air-cooled, and has fins on it to aid in the cooling process. A rod stemming from each piston is connected to a small disc, which is in turn connected to a larger flywheel. This keeps the pistons moving when no power is being generated by the engine.

The flame continually heats the bottom cylinder.

1. In the first part of the cycle, pressure builds, forcing the piston to move to the left, doing work. The cooled piston stays approximately stationary because it is at the point in its revolution where it changes direction.
2. In the next stage, both pistons move. The heated piston moves to the right and the cooled piston moves up. This moves most of the gas through the **regenerator** and into the cooled piston. The regenerator is a device that can temporarily store heat -- it might be a mesh of wire that the heated gasses pass through. The large surface area of the wire mesh quickly absorbs most of the heat. This leaves less heat to be removed by the cooling fins.
3. Next, the piston in the cooled cylinder starts to compress the gas. Heat generated by this compression is removed by the cooling fins.
4. In the last phase of the cycle, both pistons move -- the cooled piston moves down while the heated piston moves to the left. This forces the gas across the regenerator (where it picks up the heat that was stored there during the previous cycle) and into the heated cylinder. At this point, the cycle begins again.

You might be wondering why there are no mass-market applications of Stirling engines yet. In the next section, we'll take a look at some of the reasons for this.

## Why Aren't Stirling Engines More Common?

There are a couple of key characteristics that make Stirling engines impractical for use in many applications, including in most cars and trucks.

Because **the heat source is external**, it takes a little while for the engine to respond to changes in the amount of heat being applied to the cylinder -- it takes time for the heat to be conducted through the cylinder walls and into the gas inside the engine. This means that:

- The engine requires some time to warm up before it can produce useful power.
- The engine can not change its power output quickly.

These shortcomings all but guarantee that it won't replace the internal-combustion engine in cars. However, a Stirling-engine-powered hybrid car might be feasible.

To see another video of the solar-powered Stirling engine, click youtube.com.