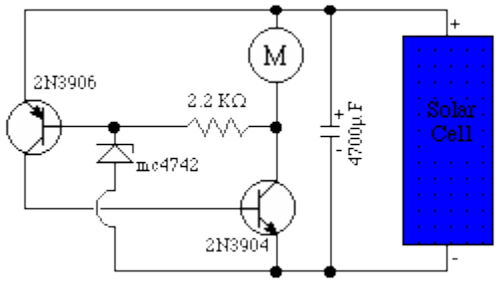
THE ZENER-BASED SOLAR ENGINE

The Zener solar engine is, as its name implies, a simple type 1 solar engine based on a Zener diode. This is the original solar engine design, by Mark Tilden, no less!



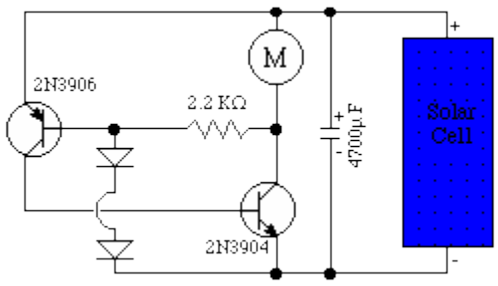
How it works (simplified)

The capacitor charges until the PNP transistor (here shown as a 2N3906, but you could also use a BC327) receives base current through the Zener and turns on. Then the NPN transistor (here shown as a 2N3904, but you could also use a BC337) turns on and the capacitor is discharged through the motor. As the NPN turns on the 2.2K resistor starts to supply base current to the PNP and the circuit snaps on. When the capacitor voltage drops below about 1V, the the PNP turns off, the NPN turns off and disconnects the motor from the capacitor which starts to charge up again.

The voltage across the capacitor rises slowly as it is charging from the output of a solar cell. This voltage also appears across the Zener in series with the PNP base emitter junction.

The 2.2 KOhm resistor is connected in series with the motor to the cap and both are in parallel with the base of the PNP. When the voltage across the Zener rises above the Zener voltage, it starts to conduct. Now a trickle of current passes through the 2.2K resistor and the motor and until the current rises to 250uA, the voltage drop at the base of the PNP is less than 0.6V. At that point
the PNP base voltage is high enough for the PNP to start to turn on. This applies current to the base of the NPN transistor , which then provides a direct motor current path. As the NPN collector voltage drops to 0V, the current through the 2.2K resistor reverses and starts to supply the base current for the PNP, taking the Zener diode essentially out of the circuit. The motor draws current until the voltage on the storage capacitor is down to about 1V.

Note that you can replace the Zener diode with one or two diodes in series (trip voltage = 0.5V times number of diodes), or with LEDs in series (trip voltage = 1.4V times number of LEDs):



Wilf Rigter's comments on this SE:

The problem with this simple SE design is that it only works with just the right components, the most important of these being the motor. If the motor is too big or inefficient it will not work at all. If the motor is just slightly out of range of the required parameter you may be able to get it to work here by replacing the 2.2K resistor with a 10K pot and adjusting it to get reliable operation. Once set up the pot can be replaced with an equal fixed value resistor. The circuit as shown generally works OK with a 30 Ohm motor over a narrow range of light conditions.

SE designs using FLEDs work better, and using a 1381 [see the 1381-based, "Miller," and VTSE designs -- Ed.] makes the solar engine much more tolerant to motor types.

Source: http://www.solarbotics.net/library/circuits/se_t1_zener.html