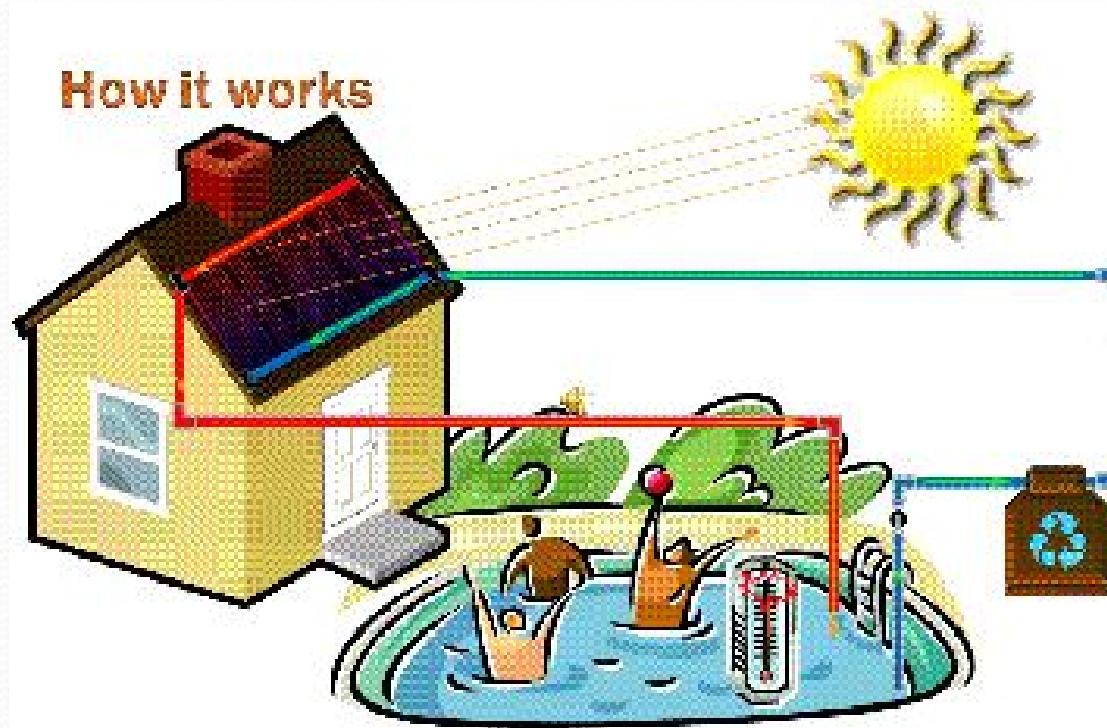


Autonomous Solar Pool Heater

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Sbaglia

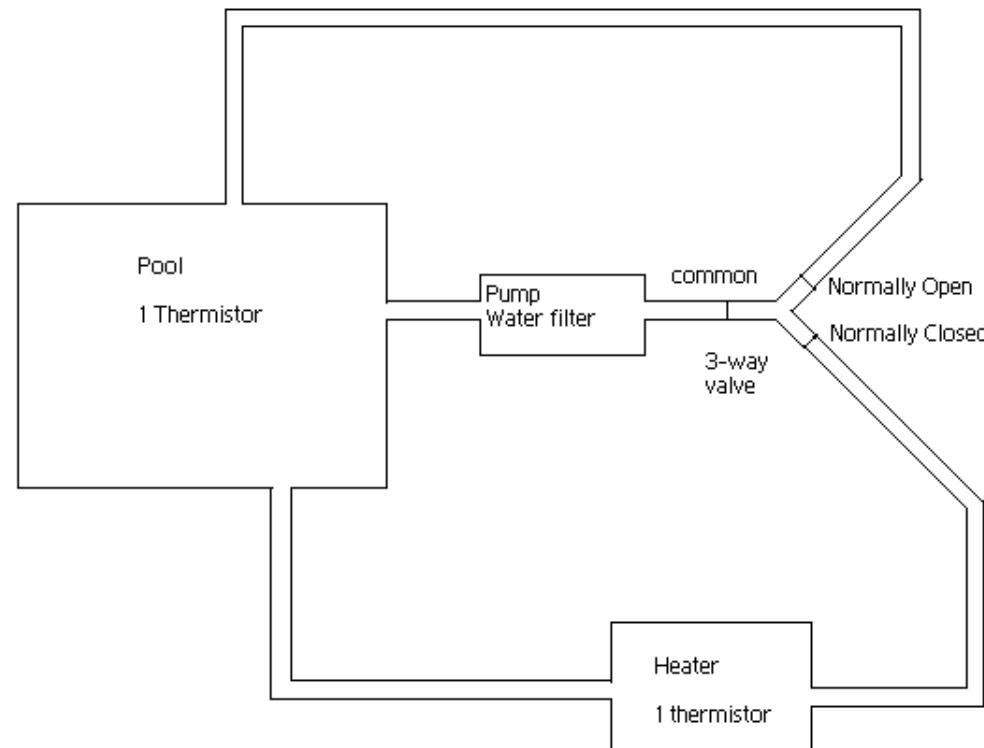
Solar Pool Heater

- A gas or electric pool heater can be quite expensive
- Solar heaters can be a great low cost way of heating up a pool but they come with their own set of challenges



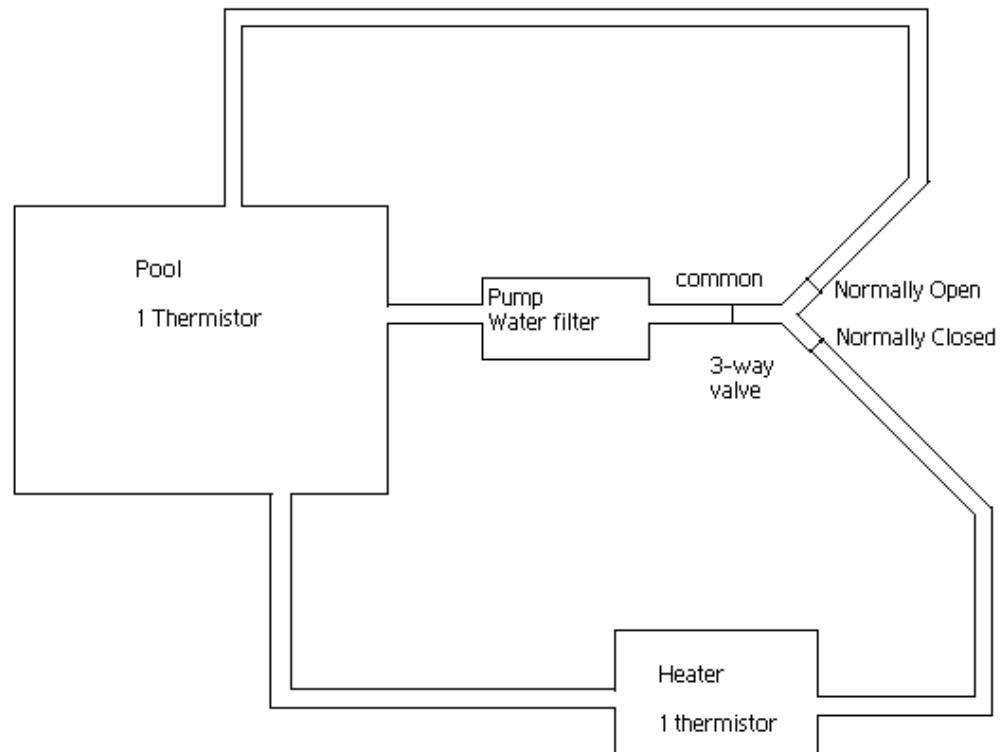
Project scheme

- The system will consist of two thermistors, two valves, a water pump and a solar heater all interfaced with our BS2 Controller
- Thermistor T_1 will be placed in the pool. Thermistor T_2 will be placed in the solar fixture



How it works

- The pump will send water through the filter, and into a three way valve. Normally, water will flow through the NO port of the valve directly back into the pool.
- As T_2 becomes greater than $T_1 + 10^\circ\text{C}$, the valve will actuate, sending water through the solar fixture and heating the pool. If T_2 falls below the lower threshold of $T_1 + 8^\circ\text{C}$, the valve will revert back to its original state and send water back into the pool.

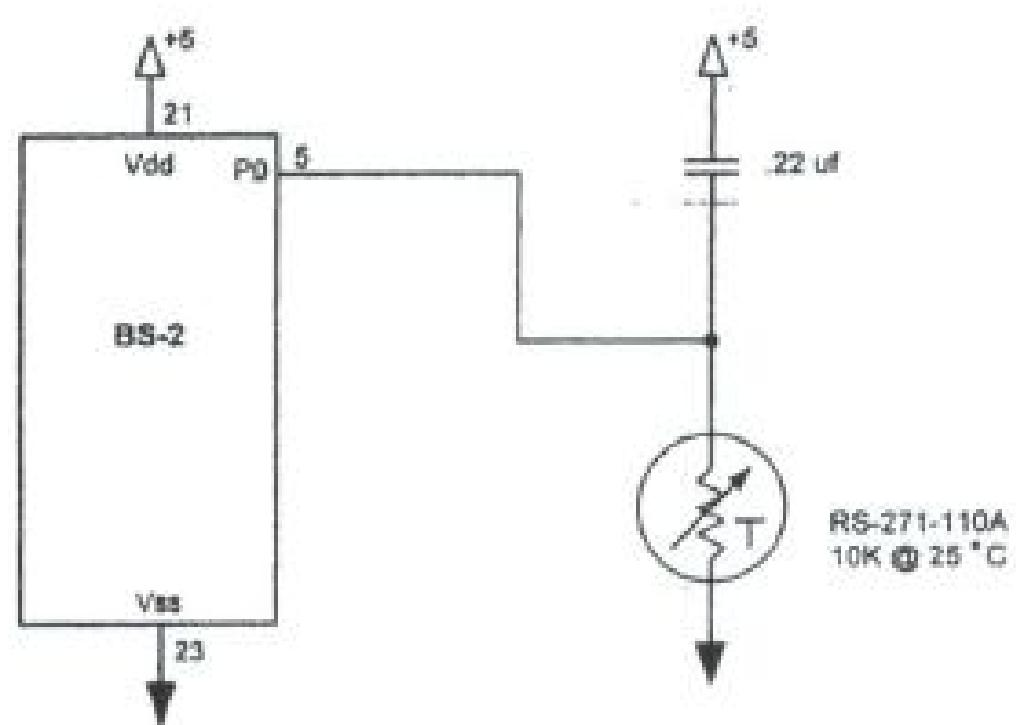


Project Core: Thermistors

- For temperature measurement two separate RC circuits are used, with thermistors as variable resistors
- AD592 thermistors
- In order to protect BS2 we use 220Ω resistors
- $C = 0.1 \text{ F}$
- For calibration of the AD592 thermistors :

$$RC_{time} = \frac{\text{Constant}}{T(K)}$$

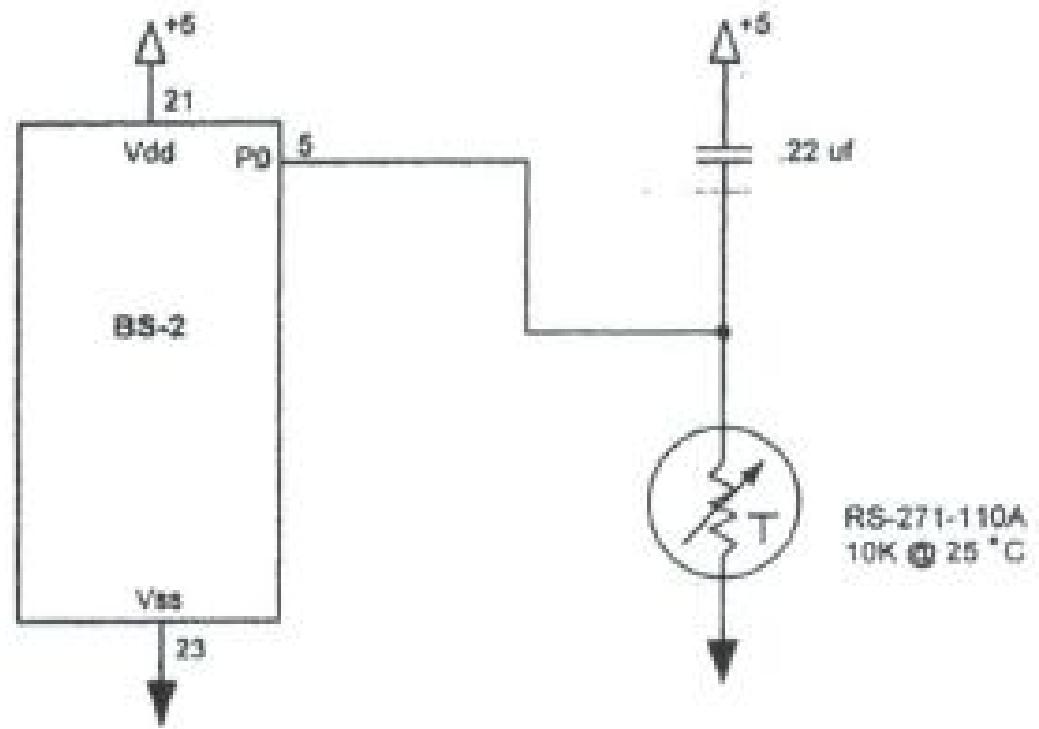
- Because they can be assumed to be linear within a smaller operating range, we calibrated at 20°C which is within our operating range



Project Core: Thermistors

- We used a digital temperature sensor which was already calibrated as the basis for our calibration
- Each Thermistor RC Circuit was calibrated separately due to tolerances in resistance and capacitance values
- $RCtime_1 = 833$
 $RCtime_2 = 858$
- $C_1 = 833 \cdot 293(K) = 244049$
 $C_2 = 858 \cdot 293(K) = 251394$
- The constant values exceed the word size variable for BS2 (0-65536), therefore we divided C_1 and C_2 by 4

$$T_1 = \frac{C_1}{RCtime_1} - 273$$

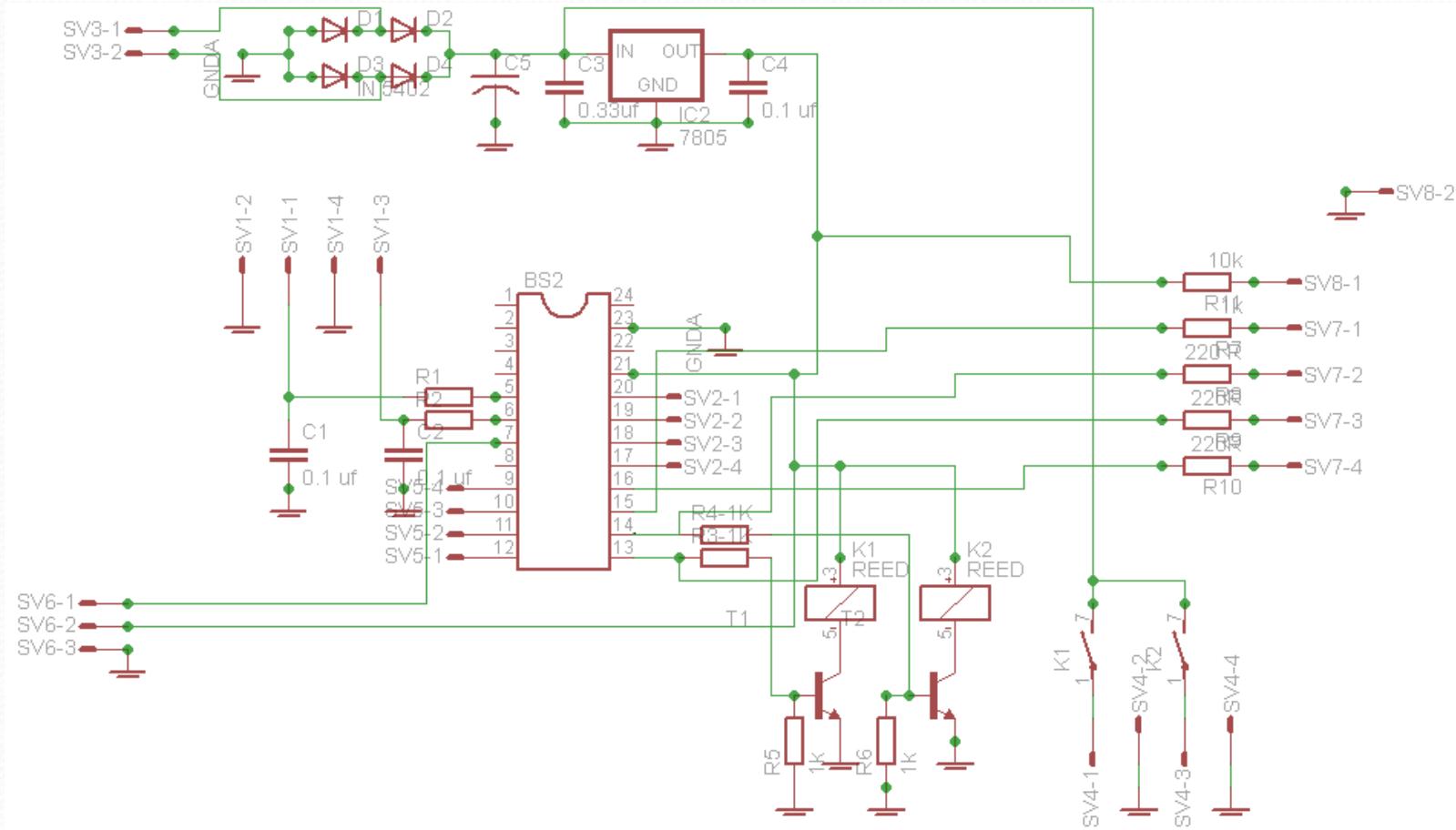


$$T_2 = \frac{C_2}{RCtime_2} - 273$$

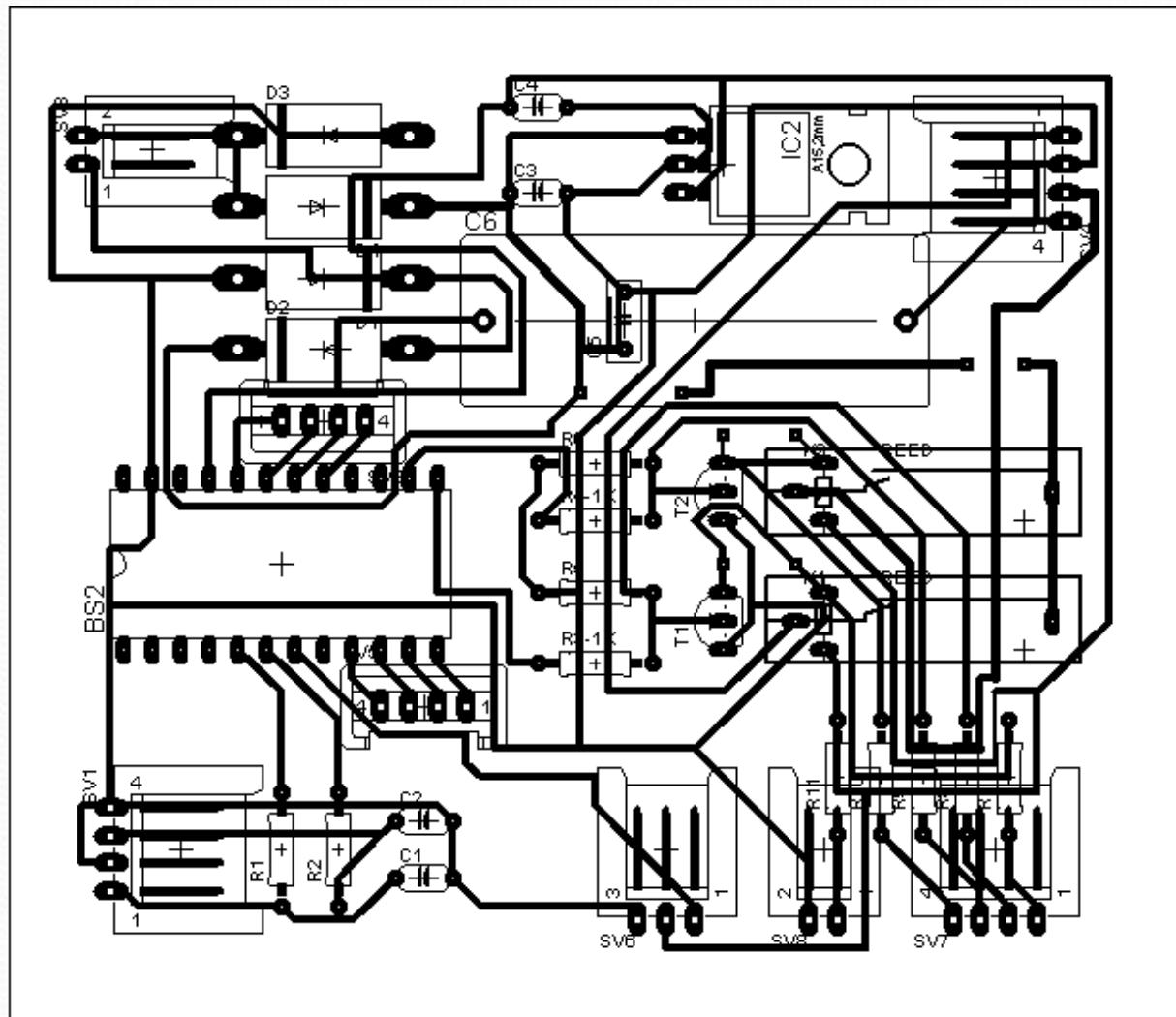
Bill of Material and Prototype Cost

Quantity	Material	Estimated cost	Mass production per unit
1	3 way Solenoid Valve ½" NPT	140\$	60\$
1	Solar Heater (optional)	150\$	80\$
50 ft	Tubing	10\$	3\$
1	Basic Stamp 2	50\$	25\$
2	Relay 120V (15A)	200\$	75\$
2	Thermistor AD592	30\$	3\$
2	Transistor	1\$	0.25\$
11	Resistors	2\$	0,5\$
5	Capacitors	10\$	4\$
1	Voltage Regulator IC	2\$	1\$
4	Diode	5\$	2\$
1	110/24-0 Transformer	6\$	3\$
	PCB Production		3\$
	Labor cost		30\$
Total (with Solar Heater)		606\$	290\$
Total		456\$	210\$

Electronic Circuit Diagram



PCB Diagram



Analysis advantages

- Solar heaters have a clear cut advantage over Gas and Electric heaters for long term Cost
- For example, the amount of energy needed to heat a 7,500 gallon pool by one °F would be 60,000 BTU's
- A cubic foot of gas cost \$2.34 on average and has 1,000 BTU's of energy.
- At that rate it would cost \$140 per °F or \$252 per °C
- Solar heaters are also better for the environment. While natural gas is a clean burning fuel in comparison to coal and gasoline, it still emits greenhouses gases
- A typically pool heater with control circuits and valves costs approximately \$4000. The estimated cost of our model is under \$1000

Heat Pump Pool Heater	Gas Pool Heaters
How Does It Work? A Heat Pump uses electricity to operate. They are actually a form of solar heater, as the sun-warmed air contributes to the efficiency of these units. This heat is extracted from the air, upgraded with a compressor, and then transferred to the water.	How Does It Work? Gas Heaters use natural or propane fuel. The gas is burned in a combustion chamber where the heat is transferred to the pool water. Operation requires a storage tank for propane gas, or hookup to natural gas, where available.
System and Installation Cost System unit cost range: \$2400 - \$4600 Installation cost: \$350 - \$950 Typical 15x30 pool: \$3200 Unit \$4200 Installed	System and Installation Cost System unit cost range: \$2400 - \$4600 Installation cost: \$350 - \$950 Typical 15x30 pool: \$3200 Unit \$4200 Installed

Analysis disadvantages

- One disadvantage to using solar power is that the amount of heat energy generated in a given day is beyond your control
- For example, a gas heater could be turned on at will, while with solar energy, it will only work on a sunny day
- A solar heater will provide less power than an electric heater. This means it will take more time to heat up a pool compared to gas heaters
- A disadvantage of our design is that the temperature threshold is hardcoded and therefore doesn't allow the user to modify it without a computer; a future design may include a potentiometer or button to allow the user to modify this value without the need for a computer



Thank you

For your attention