The Botanical Gardens of the Ozarks was created by the Botanical Garden Society of the Ozarks (BGSO), a self-described homegrown, grassroots organization established in 1994. The Botanical Gardens are located on 100 acres of property at the south east edge of Lake Fayetteville. The Botanical Gardens provides lifelong learning with workshops, lectures, and classes. The local school children are offered programs at school and at the Garden including a broad array of garden-related topics, with wild plants, animals in the garden, health and wellness, sustainability, and garden and floral design. The Little Sprouts is offered for younger children.

System Components

The first part of the system employs three power components:

1) Human
   Power in = \( \text{kilocalories} = 813 \text{ kcal/day} \)
   Power out \( \rightarrow \) Joules per second (watts) = 63.01 Watts of energy available as calculated.
   From the estimated energy available* - 813 kcal/day, with 20% usable for 2 minutes at a time, we get:
   \[
   (162.6 \text{ kcal/ day}) \times (1 \text{ hr}) \times (2 \text{ min}) = 1.8066 \text{ kcal/ min}
   \]
   \[
   (1.806 \text{ kcal}) \times (4 \text{ kcal/ 0.019m}) \times (39/34) = 734.56 \text{ RPM}
   \]

2) Bicycle
   The human energy is converted to mechanical energy losing 5% efficiency, when the child pedals the bike.
   Power in \( \rightarrow \) 63.01 Watts
   Power out \( \rightarrow \) 63.01 Watts x 95% eff. = 59.86 Watts

The low estimate for revolutions per minute (RPM) input to the pedals is 40 RPM from the child, with a gear ratio of 34:39, so the RPM of the tire, as equal to the rear gear, calculates as:

\[
(40 \text{ RPM}) \times (39/34) = 45.86 \text{ RPM}
\]

Using the power equation \( P = T \omega \), where \( P = \text{power} \), \( T = \text{torque} \), \( \omega = \text{angular momentum} \), and \( T = \text{Force x distance} \), the force between the tire and the pump is found as:

\[
P = T \omega = F \times d \times 2 \pi
\]

Insert substitutions and rearrange,

\[
F = \frac{P}{d \times 2 \pi}
\]

Substitute values,

\[
F = \frac{59.86 \text{ W}}{0.01905 \text{ m}} \times \frac{45.86 \text{ RPM}}{60 \text{ RPM}} = 40.85 \text{ N}
\]

3) Pump
   We used a positive displacement pump, so the power output is directly related to the RPM turning the shaft of the pump.
   Power in \( \rightarrow \) 59.86 Watts
   Power out \( \rightarrow \) 59.78 Watts (should equal power in here)

Components and Testing

To find the RPM turning the pump shaft:
For the bike wheel (30.5cm radius) to the pump shaft:

\[
\text{RPM} = \frac{2 \pi \times \text{radius}}{d} \times \text{time}
\]

For the bike wheel (30.5cm radius) to the pump shaft:

\[
\text{RPM} = \frac{2 \pi \times 0.305 \text{ m}}{0.01905 \text{ m}} = 734.56 \text{ RPM}
\]

To check power output using force and RPM found:

\[
P = F \omega\]

\[
P = (40.85 \text{ N}) (0.019 \text{ m}) (734.56 \text{ RPM}) = 59.78 \text{ W}
\]

The power calculation estimate is consistent with the testing done on the pump at differing RPM.

Outcomes Produced

3) Electric Power Generation
The shaft of the wheel turns the generator, lighting the LED light display.

While all the engineered components to the system have been prototyped, a complete, aesthetic design is still being finalized with input from our client.

The final outcome from the energy taken in as Calories will be an LED light display.

Future Enhancements

Our team would like to see the addition of a solar pump to fill the reservoir. We would also like to incorporate a wind turbine into the design, as we feel these additions would greatly add to the renewable energy education we wish to provide with this feature.

Sustainability

The successful completion of this project will benefit the Botanical Gardens, and its visitors by enhancing the overall aesthetic and educational values of the Botanical Gardens which are important aspects of the Botanical Gardens’ mission statement. Learning centers and community gathering places are essential to the social aspects of sustainability.

The educational value of this water feature can have ecological benefits to the managed systems by giving people a greater understanding of the amount of work required to generate even a small amount of energy. This understanding could lead to energy conservation decisions being consciously made by people who use this educational water feature.

Engineers are taught to address the sustainability of built systems while evaluating the life of their designs, and the most efficient and friendly use of the materials available.