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P3_1 The Power of the Mediterranean Sea

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Abstract

This paper investigates the potential hydroelectric energy that could be generated from draining the entire Mediterranean Sea. We assumed that it is possible to drain the entire sea and calculated that it could supply the Globe with its current electrical power consumption for the next 102 years. However, the subterranean infrastructure required for such a feat is non-existent and as such this project is unfeasible.

Introduction

The idea of draining the Mediterranean Sea has been considered a number of times throughout history and fiction; most notably by the German architect H. Sörgel. His vision was to unite Europe and Africa in a utopian continent, supplying water to the Sahara desert [1]. The draining of the Mediterranean would require a dam (or a series of dams) across the Strait of Gibraltar. This paper will continue the 2012 journal of special topics study *A1_5 Draining the Mediterranean* [2] and consider the power that could be produced by a hydroelectric dam.

Theory

The *A1_5(2012)* [2] paper considered siphoning the sea water from the Mediterranean into a series of subterranean tunnels. This paper concluded that it is possible (assuming that the infrastructure were there) to drain the Sea in 35 years. The model was based on a drainage system similar to the Hoover Dam; we will consider this same system. We will begin with Bernoulli's equation,

$$P + \rho g h + \frac{1}{2}\rho v^2 = constant, (1)$$

where P is the pressure, ρ is density, g is acceleration due to gravity, h is the vertical displacement of the water and v is the velocity of the flow. In can be shown (as in *A1_5(2012)* [2]) that when siphoning water between two containers the volume flow rate is

$$V_{rate} = \pi r^2 \sqrt{2gh} \quad (2)$$

where V_{rate} is the volume per second and r is the radius of the siphoning tube. The power generated by this can be calculate from the mass flow rate and specific work, along with the generator efficiency. We will also introduce a new factor N, number of siphoning pipes as this will increase the overall flow rates.

$$M_{rate} = \rho V_{rate} = \rho \pi r^2 \sqrt{2gh} \quad (3)$$

and,

$$specific\ work, W = gh \quad (4)$$

where M_{rate} is the mass flow rate of each pipe, and W is the specific work. We can then calculate the power produced,

$$P = \eta N M_{rate} W = \eta \rho N \pi r^2 \sqrt{2(gh)^3} \quad (5)$$

where P is the generated power, and η is the generator efficiency.

Discussion

We applied the conditions outlined within the *A1_5(2012)* [2]; r is 7.625m, N is taken as 280 and the vertical displacement, h, is 220m. We also let the efficiency, η, to equal 0.9 [3] and the density of the sea water to be 1025kg/m^3. Inputting these values yields a power output of 6.68x10^{12} W. When considering global power usage GWh/yr is a commonly used unit of measurement. Hence the power output from draining the Mediterranean Sea is 5.86x10^7 GWh/yr. This power supply would last 35 years with the suggested volume flow rate. The world's current electrical power usage is 2.04 x10^7 GWh/yr [4]; far less than the suggested possible output. To avoid an excess of power being produced equation (5) to calculate the number of pipes needed to meet the current global requirement. The resulting equation is

$$N = \frac{P_{required}}{\eta\rho\pi r^2\sqrt{2(gh)^3}}. \quad (6)$$

By letting $P_{required}$ equal to the current power requirement, we can conclude that only 97 pipes would be needed to supply the globe with electrical power.

This decrease in N would also decrease the total flow rate, allowing power to be generated for longer than 35 years as previously suggested. If we assume that the global electrical power consumption stays constant, the lifetime of this power generation can be calculated. We will use equation (5) from A1_5,

$$t = \frac{V}{N\pi r^2\sqrt{2gh}}, (7)$$

where V is the total volume to be drained and t is the total time taken. The surface area of the Mediterranean Sea is 2.5x10^{12} m^2, and it has an average depth of 1500m; hence an estimated volume of 3.75x10^{15} m^2. Taking N as 97, this power would generate for 102 years 56 days.

Conclusion

To use the Mediterranean Sea as a source of hydroelectric power would be of considerable benefit. To be able to generate over 100 years' worth of green electrical power would be advantageous to a world in which its main power (coal/oil/gas) [5] resources are declining and environmental impacts questioned.

However, the feasibility of this feat is extremely doubtful; the vast subterranean infrastructure needed does not exist. The requirement of these tunnels is compulsory for the proposed project.

Nevertheless there is still some viability to this type of project. Future studies could investigate whether flooding low elevation (<0m above sea level) land could provide a partial solution.

References

[1] http://www.scifiideas.com/related/atlantropa-draining-the-mediterranian-sea/ last accessed on 05-10-2013.

[2] P. Edwards, L. Allen and J.Wynn, *A1_5 Draining the Mediterranean*, PST **11**, (2012).

[3] U.S. Bureau of Reclamation, *Hydroelectric Power* (July 2005), p.2.

[4] International Energy Agency (IEA), *Key World Energy Statistics* (2013), p.48

[5] International Energy Agency (IEA), *Key World Energy Statistics* (2013), p.28