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Analysis of the Current Nonrenewable Energy Sources & Establishment of a Linear Gravitational Storage Unit

Rashawn Carter

Research Scholars Program, Harvard Student Agencies, In collaboration with Learn with Leaders

ABSTRACT

Wind, sunlight, and water are examples of renewable energy sources. However, their reliability is questionable. In a time when the world is changing due to climate change's impact on Earth (dust storms, forest fires, & etc.), humans have hoped to rely on something that would keep them safe and warm; we have looked to rely on energy. Unfortunately, few power sources can meet this immediate demand or maintain homeostasis without negatively affecting their surroundings. This demand/call for more relatively environmentally-friendly energy sources is where AeroGrav comes in. AeroGrav, a linear gravity storage unit, can store energy in a renewable system until needed. AeroGrav allows us to use these energy sources without adverse environmental effects. Overall, the desired outcome is to have the largest amount of efficiency possible, therefore utilizing the most stored energy. I plan to implement the project by tackling alternative energy sources with the help of simple sciences. AeroGrav takes electrical power, which is converted then into gravitational potential energy by raising a magnet. As the magnets are released, it generates electrical energy by falling through a coil. In this experiment, I will optimize energy output by tuning our controlled variables of the terminal velocity, the magnetic dipole moment, the conductivity of the coil, the inter-radius of the wire, and the thickness of the pole. Observing their values allows me to see how they influence power delivery. This system would supply energy to homes, offices, and buildings.

INTRODUCTION

With the world moving into an age of clean energy and research, observing our energy sources has become more prevalent. Clean energy is built based on the usage of nature. I have observed that nature is unpredictable and that unpredictability must be factored into our overall energy output from clean energy. From the need for a roaring river nearby to an open skyline, nature limits the productivity of our energy sources because it is an ever-changing force, meaning our energy would be ever-fluctuant. Humans look to sources like lithium batteries for support, but their mining and processing of its components can kill fish up to 150 miles away (1). As humans, we believe that we're safe when we seek to use nature's greatest gift, water, to make energy, but its usage can lead to the destruction of wildlife habits and land when moved upstream or downstream (2). Despite the environment being degraded through these resources, humans still use them because of all the power they provide/store and their overall efficiency (70-90%). Our clean energy storage methods are not reliable and ethical when their means of production affect wildlife and rely heavily on unpredictable forces. This dilemma of reliability and ethicality is what fuels AeroGrav. AeroGrav is a series of magnets within a wind turbine whose gravitational energy is used and converted into electrical energy as it free-falls through a linear conductor. Unlike other renewable energy sources, AeroGrav is a system within itself, meaning it only requires itself to function correctly. The stored energy moves a series of magnets to an extreme height. From there, it stays until needed. When it is required, it's dropped, turning all of that gravitational potential energy (PEs) into kinetic energy, which will become electrical energy. Again, this system takes the energy once generated and guides it to a new path that will eventually return to a similar form. Ideally, this form sounds realistic and plausible, but it may also raise questions like why choose a wind turbine. Wind turbines are 100 meters, so with wind farms, engineers can craft a system similar to AeroGrav, where we have multiple 100-meter drops, and we would not have to worry about needing to be near a river or such. It does not need certain conditions or locations, meaning it could exist anywhere.

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Materials:

- Python was used to help generate the data.
  - Exclusively Python used because Python is a versatile programming language applicable in many situations, which is very useful when showcasing fundamental physics in condensed form.
- Laptop (Dell Inspiron 7500, 1TB)
- JupyterLabs Notebook.
  - JupyterLabs Notebook allows users to compile all aspects of a personal data project in one place, making it easier to show the entire project process to your audience.

METHODS

After researching topics surrounding our given variables of height and overall wind turbine design, it became apparent that the world's current sources of energy and storage rely heavily on specific locations or conditions. Again, other sources have shelf-lives like batteries or could damage the environment, for example, the creation of hydroelectricity. AeroGrav would avoid these problems and is expected to increase its efficiency by working within itself. This process involves taking multiple magnets and having them fall through a conductor while being attracted to a pole. As it falls, energy should be generated from the once gravitational energy turned kinetic, turned electrical power (3). Most of AeroGrav was conducted in retrospect to data collected on Illinois because of its significant energy consumption rate, as it is the 5th highest energy-consuming state in America, according to data taken in 2022 (12). On top of that, Illinois is 4th in crude oil capacity. Therefore, using Illinois would allow society to see that clean and reliable energy production/storage, a current significant issue, could be tackled even in one of the top 5 energy-consuming states in the USA. Upon knowing these facts about AeroGrav's design, there are a few factors we, as scientists/engineers, must consider in this conversion process.

RESULT AND ANALYSIS

Factor #1: Terminal velocity is the maximum velocity attainable by an object. Therefore, the velocity in AeroGrav contributes to the efficiency, affecting AeroGrav's output. This means the higher the terminal velocity, the lower the efficiency, and vice versa (3). In addition, understanding such variables as the thickness of the pole (the magnets will travel down), the magnetic dipole moment, the conductivity of the coil, and the inter-radius of the wire (3) contribute to the movement of magnets and the generation of electrical energy as it goes through the ferromagnetism process (4).

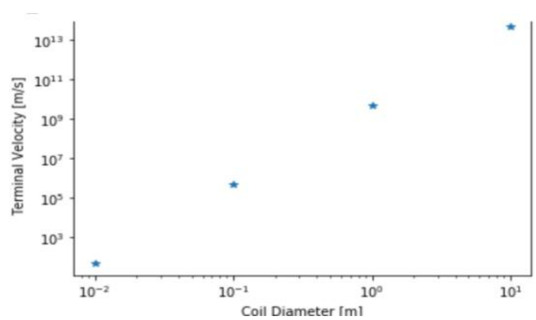

Figure: 1Source: JupyterLabs

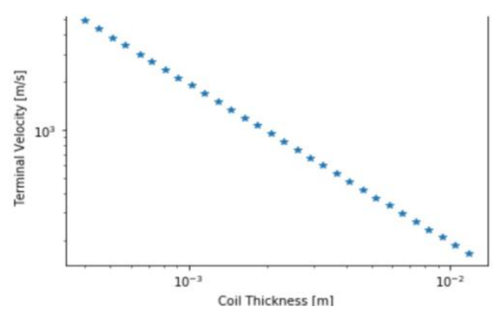

Figure: 2 Source: JupyterLabs

```
[17]: print(eop,muOpt,aop,sigma) #opt perimeters
0.0117 8.02439024390244e-08 0.01 35800000.0
```

Figure: 3 Source: JupyterLabs

These images highlight the optimized variables compared to the terminal velocity. This is very important in this situation because to optimize variables, we must compare them to the terminal velocity, which is the factor/controlled variable we want to reduce, as it removes energy from AeroGrav's output.

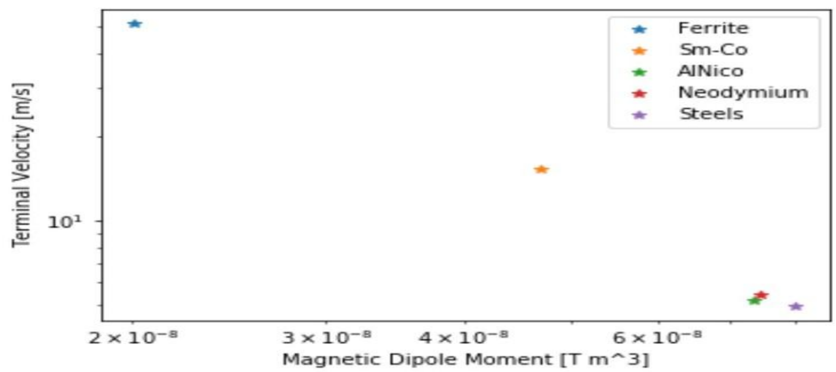

Figure 4 Source: JupyterLabs

```
[16]:
mu=np.array([4.7*(10**(-8))])*np.array([0.35,1.16,1.28,1.3,1.4])/1.16 #
relDen=np.array([5,8.2,6.8,7.3,7.75])/8.2 #(Ferrite,Sm-co,Alnico,Neodym
mu=np.array([4.7*(10**(-8))])*np.array([0.35,0.82,1.28,1.3,1.4])/0.82

a=aop
e=eop
sigma=sigma
mass=1
Ks=k(e,sigma,mu,a)
mat= ["Ferrite","Sm-Co","AlNico","Neodymium","Steels"]

[plt.plot(mu[i],vterm(mass*relDen[i],Ks[i]),'*',label=mat[i]) for i in
plt.loglog()
plt.xlabel("Magnetic Dipole Moment [T m^3]")
plt.ylabel("Terminal Velocity [m/s]")
plt.legend()
muOpt=mu[4]
```

Figure 5 Source: JupyterLabs

As seen above, we log the potential of AeroGrav when given the optimal values and material. At the beginning of this project, we realized that AeroGrav would only be good as the magnets operating within it. So, I researched several magnetized metals that could be useful in crafting the magnetic dropping system within AeroGrav. My research extended to materials like samarium-cobalt, ferrite, alnico, neodymium, and steel which all have their own densities (5)(6)(7)(8) and varying magnetic moments (9). Here, I labeled two magnetic moments (mu), the first being the optimistic magnetic moments and the second being the pessimistic ones. The labeling of both happens because the research gathered has varying information on the strength of the magnetic moment for the materials. Still, I used the first one in the end because we expect AeroGrav to use only the best materials. These moments were found by looking at these materials' remanence when their magnetic moment comes into play (9).

Factor #2: As scientists, we must observe/analyze the forces and energies at bay, such as gravitational, kinetic, and electrical energy. They hold an essential role as they are the transitions and need to be understood to see the overall efficiency in the end. After researching our controlled variables, Python was use to understand the optimization process and the units needed to create the greatest efficiency. Once tested, given variables/values were placed within different code situations. This experiment inspired the definition of our critical units and variables, which includes such definitions as "def PE(m,h)" (more in supplementary documents). Examples like these lead to identifying the optimized variables and materials and how they're achieved.

```
[3]: masses = np.linspace(0.1,10,1000)#gm

[ ]:

[4]: heights=np.linspace(0,100,num=1000)

[5]: energies=[PE(masses[i],heights) for i in range(len(masses))]
```

Figure 6 Source: JupyterLabs

Here I begin setting possible masses, heights, and overall energies present (when the varying masses are compared to the fixed heights at multiple points). Here we name more variables.

```
[6]: maxE=np.max(energies,axis=1)#Highest Energy for each mass

[7]: FreeE = [maxE[i] - energies[i] for i in range(len(masses))]

[ ]:

[8]: velocities=[v(masses[i],FreeE[i]) for i in range(len(masses))]
     KEs=[KE(masses[i],velocities[i]) for i in range(len(masses))]
```

Figure 7 Source: JupyterLabs

This is our first sight of maxing out variables, with max Energy representing the energy peak at each mass. Next, these transition into how much Free energy (FreeE) is left, which is generated by noting present energies at play and subtracting them from the MaxE. From here, this moves into defining our Kinetic energies and velocities.

```
weigh=500000
Nmag=weigh/masses[Optmass]# Number of the magnets that can be fit in 10%
WindT=Power[Optmass]*Nmag/1000000 #Represents the power per wind turbine

print(Nmag,WindT)

WindFa=WindT*414 # represents the power of the entire wind farm in India
Homesy=WindFa*175 # Represents number of homes per year that could be po
Ill=Homesy/5388066 # percent of Illinios that could be powered by AeroGr

print(WindFa,Homesy,Ill)

97762.90294169456 48.04827858660343
19891.98733485382 3481097.7835994186 0.6460755
647015866
```

Figure 8 Source: JupyterLabs

This data is compiled specifically in retrospect of Illinois and its housing numbers (numbers provided by a wind farm in Indiana and Census Quickfacts about Illinois). This data highlights the energy conversion of gravitational to kinetic energy to electrical in our gravitational linear generator and how much of Illinois that affects if applied in the state.

DISCUSSIONS

After finishing the coding process, we understood the optimal variables and their importance in helping AeroGrav generate/store electricity. These optimal variables also come into play when trying to see how to apply these values and units to a real-life model. This helps fuel further research as it enlightens us about the needed conditions of the turbine and what is in it. These conditions and what happens with these turbines help us answer questions like how many magnets are needed for a standard turbine. Or how many will be required in the end, depending on the size of our turbine count/farm?

I presented answers that helped contribute to understanding the overall effect of our project. First, I was able to generate an overall efficiency of 63% (0.634); this seems irrelevant compared to the higher efficiency numbers being pushed out by clean energy sources like Hydroelectricity (10) and batteries. Still, from what I can see, this wind farm in Indiana with 414 wind turbines could power 64% of Illinois. This is a fantastic feat because Illinois is a giant state, and if one wind farm could power 64% of its housing (11), imagine what would come from installing AeroGrav's system within other systems worldwide. Although it can't meet competitors' efficiency levels, it is still about to provide impressive energy levels that can rival our opponents, making AeroGrav an incredible creation. It did not meet our initial expectations, but it blew us out of the water with its ability to put up a fight against other clean energy sources.

CONCLUSIONS

In conclusion, AeroGrav gave us a great sense of how clean energy storage functions. It has allowed us to evaluate/observe clean energy sources that already exist in our world, therefore showcasing their overall reliance on specific conditions produced by nature. As a result, our sources of clean energy production can damage the environment or be affected by what they look to protect. AeroGrav demonstrates we can isolate and reduce that reliance on nature's unpredictability and still develop a productive system capable of producing energy levels high enough to power states. Although I didn't receive the expected results in a higher efficiency rating and overall stored/generated energy, I still developed a system capable of rivaling the clean energy sources currently providing large quantities of energy but affecting our environment over time. It is a system that is both affordable because it exists within the preexisting system of a wind turbine and is capable of being established no matter the land's topography. With all our collected research so far, it is clear AeroGrav may not have been able to rival other energy resources regarding energy storage. Still, it makes good use of simple science, ultimately contributing to pave the way for even better science revolving around magnets.

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