Earth's Rotational Energy – Is it usable?

1) Context

Energy is becoming one of the most critical consumables of our society. We have been living of the free ride provided by the millions of years nature spent creating oil. Yes, let's face it: oil is great! Its energy density is high (a tank full of gas in my car is enough for 1400 km or more than 850 miles), it is light enough for us to carry it around (in car tanks and airplane tanks) and we have rather inexpensive engines to produce very high power with it (an 80hp car generates around 60KW of power!!). It pollutes, sure, but we don't know yet how far we can go in making cleaner engines. All in all oil is just great! Anyway, we are running out of oil. Also, the production (extraction) is controlled by few, and that generates a lot of discomfort from consumer countries.

In this context, the need for alternative fuel sources is obvious. Solar photovoltaic cells have little density and high setup cost, but are the cleanest, don't pollute, don't make noise, have nearly zero maintenance, and output the best quality energy (electricity) directly. Wind generators are ugly, have a high ecological impact, make noise, and have high maintenance and setup costs. Nuclear is dangerous and, despite popular belief, it's not unlimited. Tides have low energy density, and are not proportional to the number of people (only available at coastal lines, while the consumers may grow in proportion to a large surface of land) and may have large scale ecological impacts. Hydrogen is not really a source, since it is always already chemically bonded with something else and is not generally available for grabs. Natural gas has low density, and is also limited. Coal is cheap but dirty and pollutant. Alcohol (from corn, for example) is expensive (besides, how ethical is it to burn food to move cars while there are people dying of starvation?). Biodiesel is cheap, but smells bad and is not very efficient (besides, the best sources are residual oil, which is not an unlimited resource). What else is there?

The Earth is rotating. A large rotating mass like the Earth is a huge battery of kinetic energy. Millions and millions of tons of rock rotating is one the things closest to unlimited energy that we can think of. Probably right up there, second only to the Sun's energy. This planetary battery was charged up during the formation of our planet, but since it is a battery it can be drained. The moon and tides have been draining some of this energy for a very very long time. If we could we would certainly like to tap into it.

2) Motivation

I wrote this article because the idea of extracting free energy from the Earth's rotational energy is out there being discussed as if the problem of determining if that is possible or not were a very complex one. The fact of the matter is that it is not. It is a very simple problem to analyse.

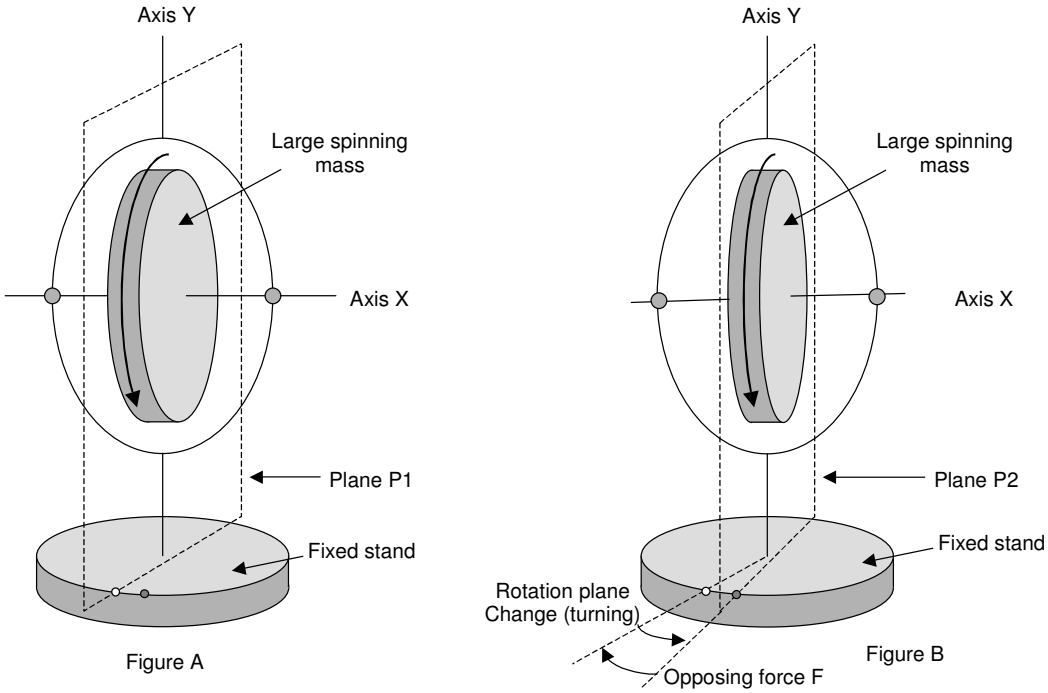
Extracting energy from the Earth's rotation is, without a doubt, possible. That has been proven since, at least, 1851. The debate should, thus, be focused on determining if the Earth's rotational energy can be extracted in any useful way. All the math I apply here is very simple, and the principles I invoke are all very well known and understood.

Some people out there will claim that you can design such a machine by solving some set of differential equations and voilá!! I intend to show that there is no magical solution that a computer can find after solving a set of N differential equations. At least not without dealing with the basics first, like forces and materials.

3) The idea

The idea is, in fact, very simple. The Earth is rotating, and Earth is a very large mass. If you can lock something to the Universe so that it doesn't turn (with respect to it), and fix something else to the world so that it turns with it, then you have yourself a movement differential that you can attach to a generator to produce electricity.

The gyroscope effect is the resistance that a spinning mass offers to turning (changing the plane of rotation in relation to the Universe). So, the gyroscope effect is a good place to start looking for things that lock themselves to the Universe.

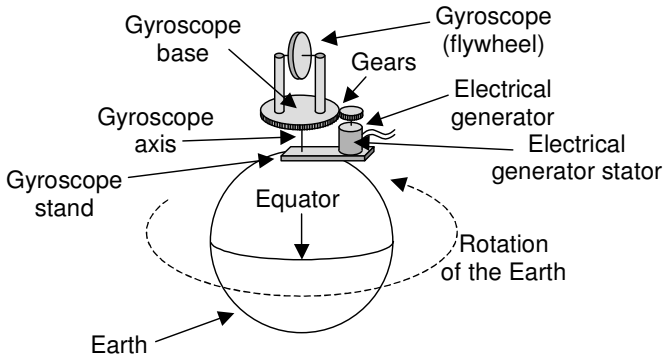


In Figure **A** there is a large mass spinning fast in plane **P1** (around axis **X**). If you try to turn the rotation axis **X** around axis **Y** so that the mass spins in plane **P2** (in Figure **B**) then you get an opposing force **F**. This is because you are trying to change the rotation plane of the mass and the "Universe will fight against that". This simplistic language just means that forces will appear that will try to keep the spinning of the mass as it was before (in plane **P1**) and will resist to changes (to plane **P2**) by opposing them. Also, **F** is not the only force resisting but it is the one we are interested in.

What is special about force **F** is that it acts continuously. This is different than for ordinary translation forces, where the force only acts when the change starts. This rotational force **F** has the peculiarity that it exists while the movement exists, and not only when it starts.

Now that we have a force that locks itself to the Universe, how can we take advantage of that to create movement, down here on Earth?

Well, the most obvious solution is to lock one part of the machine to the Universe with the above force and lock down another part of the machine to a solid rock on the ground. Then put a rotational electrical generator between them.



We first build a gyroscope on the North Pole. We could build it anywhere else, but the North Pole allows us the use of a gyroscope flywheel with a horizontal axis (which helps keep the text simple). The massive flywheel is spinning very fast, so its rotation plane is locked with respect to the Universe and will fight against turning. The gyroscope is assembled in some way to the gyroscope base. The base is free to turn around the gyroscope axis. The lower end of the axis is fixed to the gyroscope stand. The stand is bolted down to the ground so that it's fixed to the Earth and turns with it in space (a full turn every day).

The flywheel plane is locked to the Universe, so, as the Earth turns (and turns the bolted down gyroscope stand with it), the large gyroscope base gear (attached to the flywheel which is in turn locked to the Universe) makes the electrical generator gear spin (because the stator of the generator is mounted on the stand and is thus locked to the Earth). Add in a couple of wires and magnets and the rest of electrical generator stuff and you got yourself some electricity coming directly from the Earth's rotational energy.

The easiest way to understand this is to imagine yourself on top of the North Pole together with the gyroscope stand, and observe the gyroscope base turn in the opposite direction in which the Earth turns. If you actually were in the North Pole sitting on the gyroscope stand then this is actually what you would observe (the same effect seen from a different point of view).

4) Who came up with the idea first?

The idea of tapping the Earth's rotational energy is not new, it has been around for a while, and in many forms. Geologists, for example, study how tidal movement interaction with the Earth converts some of this energy to heat, and how mantle movements convert this energy into magnetic fields and radiation.

The oldest widely known reference dates back to 1851 by a French guy named Leon Foucault. He used a ball suspended on a long wire (a pendulum) and as time passed it was visible that the ball would move back and forth in a plane that was not stationary relative to the ground. This was probably one of the first science-based man-made machines that tapped into the earth's rotational energy (to overcome the wire tension). This was known to Foucault, since he knew that the Earth's rotational energy extracted would have to overcome the wire torsion resistance (and other aspects also).

An earlier but not so well known reference was the discovery of the gyroscope effect in 1817 by Johann Bohnenberger. However, no references are available which can prove that his ideas considered energy at all.

Millions have observed the Foucault pendulum in many museums around the world for several decades now. Many of these visitors inevitably thought "the Earth's rotation is causing a noticeable movement, a physical manifestation right here and now! What if…?". The oil crisis back in the 70's caused many people to take a closer look at alternative energy sources, and the Earth's rotational energy was one of them.

It seems everyone converges to the same gyroscope effect machine, since it is the most obvious solution to anyone who has ever seen a gyroscope. Some people find this an advanced concept, and think they have discovered a space-age world-saving machine when they think of it, and claim ownership of the concept. But the concept is, in fact, simple and old. It was advanced when it was first discovered, back in 1817, but since then gyroscopes have become common and so everyone these days that thinks of extracting energy from the Earth's rotation rapidly converge to the basic gyroscope architecture (even if the details vary).

However, the fact that no one knew how to even start building any useful such machine, and the fact that there was no "global internet" where to easily publicise and exchange ideas, makes it hard to determine who might have come up with the concept first.

Anyway, the oldest proof of concept ownership I could find was a patent filed in 1992 in the US (number 5313850). This doesn't prove that the concept is theirs, and also doesn't prove that they didn't think of it before 1992, but it is the closest we can get to easily finding an official "inventor" for the concept. But I know that many people out there happily claim the concept is theirs even if they don't have proof, and so they should respectfully revise their ownership statements.

So, I propose that the concept belongs to no one, like with the wheel. But if anyone happens to build such a patented machine then they probably should pay royalties to the "official inventors", unless the patent owners give it away. No one else would have the right to give it away for generalised use.

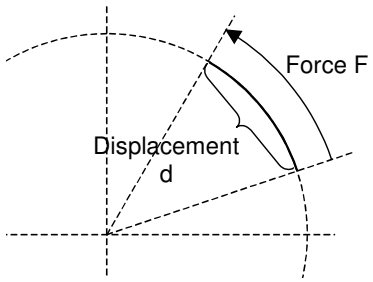
5) Can such machine be built?

You can assemble the required parts easily, so the answer is yes. You can build a machine that extracts energy from the Earth's rotation. You input 1000J to set it up and it extracts 0.0001J from the Earth's rotation energy. This is not interesting, for most applications. For others it is very interesting and useful, like the Foucault pendulum in many museums. It is useful as a tool to prove that the Earth is rotating, but not at all useful as a power source.

So I will, instead, try to answer the question: can a useful power generating machine be built? One that outputs usable amounts of energy? Much more that what was put into building it and starting it? Let's use very simple math to determine what the real problem of building such machine really is – the magnitude of the forces involved.

Let's first imagine we have a large flywheel which is perfectly locked to the Universe. This flywheel does not turn at all (with respect to the Universe) when we apply the Earth's turning force against it. Since it is perfectly locked it will keep the same rotating plane forever, in respect to the Universe, and will not turn (slip). Also, let us imagine that we have perfect bearings and that no rotation energy of our flywheel gets lost as friction, magnetism, radiation, or any other type of energy loss. If so, then it will rotate forever. Combining the 2 previous statements our flywheel will rotate forever on the same plane which is perfectly locked to the universe without turning (no slip at all). Perfect.

The rotating energy we receive from the Earth thus comes in the form of a tangential force which is applied while travelling a certain distance along a circular curve as the Earth turns:



No matter what the configuration and machine setup are, and no matter how many differential equations you propose yourself to solve to optimise the machine, if you plan to use any gyroscopic machine then the energy will have to be extracted through mechanical work. Remembering the simple Newtonian math for the mechanical energy (work) ***W*** produced by a force ***F*** applied during a displacement ***d***, then:

$$W=F.d \Rightarrow F=W/d$$

If we concentrate on how much energy we extract in a second, then ***W*** becomes equal to the power of the machine (the amount of energy provided per second), and ***d*** becomes the displacement during that one second. So, what displacement is this for the Earth? The Earth rotates once in about 24 hours. One full circle of 360 angular degrees corresponds to 2PI radians (about 6.28 radians), so this means 2PI radians in 24 hours, or 2PI/86400 radians per second (one day has roughly 86400 seconds). This is the same as PI/43200 radians per second.

Since our flywheel is perfect, it will also rotate 360º once every day with respect to the Earth, so its angular speed is also PI/43200 radians per second with respect to the Earth. If we want to compute a displacement length in meters we have to define a radius also in meters. Let's start by projecting a machine of 1m in radius.

Radians have the wonderful property that the displacement arc with 1 radian angular amplitude travelled for a given radius ***R*** has length ***R***. Also, an angle of 0.5 radians describes an arc of 0.5***R***, if the radius is ***R***. So, it is very convenient to use angular units in radians rather than in degrees for these displacement computations.

So, if our machine has radius 1m and if the angular speed is PI/43200 radians per second then the displacement ***d*** in one second is an arc with PI/43200 meters in length. This amounts to about 73um (0.000073 meters).

We are ready to calculate the force needed if we define how much power we want to get from our machine. Let us assume that we want to get an energy of 1J out every second, so the power is 1W. The force is thus:

$$F=W/d \Rightarrow F=1/73\times10^{-6} \Rightarrow F=(aprox.)\ 13700\ N$$

This is a very large force!!! This force is about the same force necessary to hold a mass of 1400 Kg against gravity, just like holding a medium size car up in the air!! And this force always exists somewhere in the machine, weather it is in a gear tooth contact point, a bearing contact point, an axis fixation point, or whatever. So, what we should do is try to minimise ***W/d*** to make the force smaller. Either we lower the power ***W*** or we increase the displacement ***d***.

We want the largest possible power, so let us not mess with ***W*** right now. The displacement ***d*** can be increased by increasing the radius of the machine (since we cannot make the Earth spin faster). This radius is not necessarily the radius of the flywheel, but is the radius of the rotating piece of our machine responsible for transferring the mechanical energy from the Earth to our electrical generator. A 10-fold increase in the radius increases

displacement ***d*** by 10-fold also. So, if our machine had been built with a radius of 10m instead of 1m then the force would have been 10 times less for the same 1W power output, yielding 1370 N, a much more manageable force.

To be useful the machine should output at least 1000W. This is double the power required by an average household, but is a good reference for houses in very cold or hot areas. Our 10m radius machine now generates forces of about 1,370,000 N, and we are back to (even worse) unmanageable forces. Maybe we can make the radius 100 times larger, up to 1km? This would lead to the original force of 13700 N, since the 1000x factor increase in the power cancels out the 1000x factor increase in displacement ***d***. And our machine now has a 1km radius (2km diameter), and is able to power up only 1 household (maybe 2 in warm climates).

So, anyone who believes that a 1KW or 2KW machine can be built inside a small room must be ready to believe that there are materials capable of withstanding very strong forces, several orders of magnitude beyond current material technology. And must also be willing to believe that such materials can be used with near-zero friction.

Now let us imagine that a material named MAGICALLOY© has been invented which has all the magical properties we need in order to avoid friction losses and withstand all the forces we subject it to. Now we can focus on our flywheel again. Let's do that.

Our machine's flywheel connection to the electrical generator turns at a rate of 73um/sec for a 1m radius. A perfect flywheel will turn 0m/sec since it will be perfectly locked to the Universe. This would imply infinite mass and/or rotation speed for our flywheel. In practical terms we have to build a flywheel that is so tightly locked on to the Universe as possible so as to turn (or slip) at a negligible speed compared to the Earth's rotation. Say 1% of 73um/sec, or 0.73um/sec. Can you imagine what mass and at what speed can generate that much resistance? Well, a simple "cosmically symmetric" overview would tell us that we would need the contributions from all atoms that constitute the flywheel to, at least, generate roughly 100 times the overall force we need to obtain at the power transmission gears. Since these spinning atoms are the ones actually doing all the work, and we only allow them to slip by only 1%, these forces are now 100 times larger than the already huge forces we found before, and are mainly lateral forces and centrifugal, which are usually not great simultaneously in most materials. Let's trust MAGICALLOY© for that.

The rotating mass and speed computations are a little more involved, but the flywheel would have to have a mass of hundreds of tons for practical speeds. It will need MAGICALLOY© bearings to hold such weight without significant friction losses. Alternatively, it can have very little mass and rotate at unimaginable speeds, with tangential speed approximating the speed of light. The centrifugal forces would be tremendous, of course, and the material would vaporize itself because the attraction forces between its constituent atoms would be overcome by the centrifugal force, and so those atoms (or blocks of atoms) would just shoot out in all spin directions! Also, the axis could not bend nor break under such overwhelming forces. When under such forces (and possibly even higher pressures) bearings would have to hold and without friction losses (bearing contact for no friction loss is necessarily mathematical point, so pressure is simply infinite). No worries, our MAGICALLOY© would do the trick.

Or we could do it with permanent magnets to avoid contact. Did I mention that MAGICALLOY© can repel with an incredible magnetic strength? And that it's magnetism can be turned off so that the rotating flywheel does not generate an electromagnetic field that would drain its rotation energy?

Setup costs would be high. We would have to inject millions of Joules into the rotating high-mass flywheel to get it to spin at high speed, and again some more periodically to account for small losses in the rotation speed. For now all energy would probably come from oil. This makes our machine expensive to build (and possibly expensive to keep), and we can only hope to recover the investment during the next… decades? And all the energy required to building a 2km diameter power plant somewhere? The material that would have to be created and all that heat and foundry work. Again, the return on the investment could take a long time. Thankfully our MAGICALLOY© is cheap to create, and objects and parts made of it are easy to shape, cut, and assemble.

So, all we need to do now is find that MAGICALLOY© material. That is the only real research issue left to crack.

My opinion? I don't believe such MAGICALLOY© material can be built. Protons and electrons just don't love each other that much to allow for the existence of materials that so flagrantly exhibit strength/mass relation properties adequate to solving this problem. Someone could, of course, prove me wrong, and I would be happy to stand corrected. Of course, some would like to rely on designing sets of unsolved differential equations, which, when solved, automatically determine how the machine should be built, mainly because that would give them hope for a while longer that the materials problem could be bypassed. Anyway, the inventor of such material could just gladly give it away to the world so that we can all benefit.

6) The effect

It is estimated that the Earth has an accumulated rotational energy of about 2.5×10^{29} J (Wikipedia). That's 250,000,000,000,000,000,000,000,000,000 J, which is a lot of energy. We are currently consuming energy at a rate of about 13.5 TW (answers.com) which is 13.5×10^{12} W or 13,500,000,000,000 J every second.

At this rate the accumulated energy of the Earth would be enough for roughly 18,500,000,000,000,000 seconds, which corresponds to more than 500 million years. In this time the Earth would come to a rotational stop. Surely we don't want that. At least there is no other predicted astrological event that is to occur earlier (like the sun's death, for example) that could make it easy on our conscience to simply pump energy out of the rotation of our blue ball until exhausted. So I would say we don't want to drain it to a halt.

Anyway, the first million years of energy extraction (at current consumption rate) would correspond to 0.2% of the Earth's rotational energy, and would slow down the Earth's day by less than 3 minutes (1 second every 5000 years).

My opinion is that if this extraction were possible then it would be negligible for many thousands of years. Adding 1 second to the Earth's day duration for each 5000 years of power output seems acceptable, but it may have unknown effects, like tide changes and magnetic field changes (and possibly others) which are hard to estimate and to predict. Geologists and biologists may know a lot more about it.

Anyway, I would argue that the day duration increase would be very gradual, and that the effect would be far less noticeable than burning oil or filling up the Sahara with solar panels or the mountains with wind generators. But, like any other limited resource, the Earth's rotation is like a battery, one that we should not drain out (contrary to what we plan to do with oil).

7) Can the Earth's rotating energy be extracted with non-gyroscopic machines?

Well, some say it can. At least I think that's what they are saying. Use your favourite search engine with terms like "earth rotational energy" and see if you can find out there. I found a few, but I will not write about them here because I may be understanding them wrong.

8) Where could these generators be used?

I would say that most certainly not on mobile stations, like cars and planes. Any generator that taps into the Earth's rotational energy is bound to have some of its parts bolted down to the Earth. So I assume only stationary power plants could use this energy source in a meaningful way.

However, if we had a cheap and clean energy source readily available we would be able to store it in batteries (under the form of chemical energy easily convertible to electricity) to power cars and other moving consumers. We would also be able to divide water molecules to isolate hydrogen (which could be used to power fuel cells even if at a relatively low overall efficiency).

We could also have enough energy to remove the salt from the sea thus converting it to water we could drink. And why not go beyond? Given enough energy maybe we could also synthesize food!

9) So what is the energy source capable of saving us from oil dependency?

I don't know. I believe in solar generators, like photovoltaic cells, since they exhibit the best properties we want in a power source, from cleanliness to low maintenance. Their setup cost is the only problem, at about 5 EUR/Wp, and seems to be stuck there. Other solar generators also combine the best properties, especially for heating. Ultimately, the Sun is the only power source we can assume to be unlimited (since it will outlast us all), which can be captured in many ways from photovoltaic cells to wind turbines.

10) Comments

If you happen to find some error in this document or if you just want to drop me a line I would be happy to hear from you! Please e-mail me to *comments@rilhas.com*.