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ACTIVE HUMAN POWER GENERATION: AS A NEW PORTION OF THE ENERGY SUPPLY

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BY

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TABLE OF CONTENTS

PREFACE

My motivations in producing this paper come from a sincere desire to make the world better. The thought process that led me to human power generation as an option to the world energy crisis began as an undergraduate, and is a synthesis of various topics disused in my classes.

It should be known that the scope of this research is hypothetical. It is limited by my understanding of the topic, my inexperience as a researcher, as well as a lack of empirical data. Although I have gone through great lengths to logically and mathematically explain my thesis it is certainly incomplete. I hope by admitting this that responses in the academic community will be focused on reworking the idea, rather than attaching me as the author.

ACKNOWLEDGEMENTS

I would like to thank the BYU library research grant committee for approving my project. Thanks to my wife Linda for providing me the opportunity to spend countless hours researching and presenting my ideas. Special thanks to Dr. Ryan Jensen for putting up with my continual drafts and missed deadlines. Also I appreciate the help of my honors 300R class in there critiques of my work, it has allowed the idea to be more understandable. Additional thanks to Dr. Madison Sowell and the Western Regional Honors Conference committee for my opportunity to present this research during the 2009 conference in Spoken, WA.

INTRODUCTION

The discovery and use of energy has revolutionized society for more then two hundred years. With it we have witnessed an explosion of knowledge and technology unparallel in history. Unfortunately our main sources of energy are in limited supply. In order to continue to enjoy the progress made during these last few centuries it is necessary to know both when our supply will run out and to find alternative sources.

The question of when the fossil fuels will run out has been on the minds of many scientists for more than fifty years. In 1956 Dr. M. King Hubbert developed a method of predicting when a particular oil field would reach its maximum production period after which it would decline. (Tsokounogiou, Ayerides, and Tritopoulou 2008) By expanding this method Hubbert predicted that the US would reach its peak in the early 70's. Although initially discredited, by the mid 70's it was obvious that Hubbert had been correct, oil production in the US had declined moving the US from being the number one oil producing country to the number three. This same method has been expanded again to create the Peak Oil Theory. According to some estimates the world will reach Peak Oil by 2023, a mere 14 years from now.(et al)

Although reaching peak oil will not bring about an end of society, it will mark the point at which the supply of oil will no longer be able to grow with demand. As this occurs oil will become exorbitantly expensive, increasing the price of every product that oil is used to produce (ie every thing in the US) and every competing form of energy.

In our search for alternative ways to meet energy demands it is important to look at all the possibilities, and to use as many of the options as we can to provide a strong power generation base. In this paper I will discuss one such option called Active Human Power

Generation. After giving an overview of its strengths and weaknesses I will make recommendations for future research.

Human Power Generation: Forms and Possibilities

Human Power Generation (HPG) is defined as using the human body to produce energy. HPG can be divided into two main categories parasitic and active. Parasitic HPG (PHPG) captures energy as the human body functions during normal daily activity; while active HPG (AHPG) focuses on generating energy as an activity in itself.[1]

Active human power generation would be any process that converts work done by the human body into energy. The simplest way to understand AHPG is to imagine a person pedaling an exercise bike. Ordinarily the work performed would produce motion and heat, but in the case of AHPG the bicycle is connected to an electric generator causing the magnets to spin and producing electricity.

As I have presented this information one popular question has been "how much energy can one-person produce." Due to the lack of scholarly research on this subject I was unable to find any first hand data to help answer this question, but I have found estimates posted on Wikipedia. By that estimate the average person can produce 3 watts of power per kilogram of a person's body weight. Assuming the average person weighs 70kilos then that person could produce about 210 watts of energy. Over a one-hour period this is enough energy to power 3 incandescent light bulbs, 3 (2008 model year) MacBook laptops, or 42 LED light arrays.

STRENGTHS AND WEAKNESSES OF ACTIVE HUMAN POWER GENERATION

[1] For additional treatment of Parasitic HPG see the appendix.

The strength of active human power generation is it can be accomplished by low-tech means. The simplest AHPG machine can be produced with a few pieces of aluminum a bicycle seat, copper coil, and some magnets. This makes it ideal for possible implementation in off the grid applications. One proof of concept comes from a group of engineering students who have created playground equipment that can power lighting for schools in developing areas using only materials that are readily available in those areas. (http://www.lightingafrica.org/).

One possible weakness of human power generation is the chance of human exploitation. For example if people in developing countries are producing electricity for a living they may never earn enough money to purchase what they are producing. Also there is a possibility that corporations may be able to convince people to produce power for nothing more then daily food and water. In proposing further exploration into AHPG it is important to address these possible problems along side empirical research into AHPG viability.

POSSIBILITIES OF FUTURE DEPLOYMENT OF AHPG

Active human power generation could be implemented through for profit corporations, or gyms. In 2008 the average price of US electricity was around $.11 per kilowatt-hour.(US Department of Energy) According to the CIA World Fact Book there are currently 24 countries in the world that earn a per capita GDP of less then $1200 per year. Assuming the same basic working conditions as the US these individuals earn about $.114 per hour. By my estimations all of these counties could begin to produce AHPG for export and still retaining a profit once the price per kilowatt-hour increases above $.57 per kilowatt-hour.[2] [3]

[2] In 2008 Hawaii averaged $.33 per kilowatt-hour
[3] See figure one for the actual calculations.

In the United States the current environment lends itself to creating AHPG subsidized health clubs. Virtually all exercise equipment can be altered to produce electricity. A popular club could produce enough power to meet its own needs and occasionally could feed excess power to the grid, while smaller less popular clubs would lower their utilities costs by upgrading there equipment. The effect of this trend on the supply of energy could do much to alleviate the impending crisis if a large portion of the population regularly worked out using AHPG exercise equipment.

THE NEXT STEP FOR AHPG

For this paper I drew on a large number of sources in an attempt to synthesize a place to start the conversation on active human power generation. For the potential of AHPG to truly be known a far greater amount of empirical study needs to be done. Some specific areas that need to be addressed are how to efficiently produce electricity at the low RPM's produced in AHPG, how to best implement AHPG and avoid human exploitation, as well as the best way to deliver the energy produced though AHPG to market.

CONCLUSION

The purpose of this research was to create a starting point for an academic conversation about AHPG. I suspect that active human power generation will be a viable means of augmenting the world power supply within my lifetime and I hope that those who read this will be willing to put forth some effort in there respective field of study to test this proposition thoroughly so that when the time is right AHPG can take its place as a part of the new energy culture.

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APPENDIX

Additional Information about Parasitic HPG

The following lists some technologies that can be implemented as parasitic HPG devices.

1. Thermoelectric generators: These devises absorb heat and produce electric currents. (Encyclopedia Britannica)

2. Piezo-electric generator: These generators absorb physical compression and produce electric currents. (et al)
3. Accelerometer: These absorb kinetic energy and produce electric currents.

Using a combination of parasitic human power generators it is possible for individuals to power their entire collection of personal electronics with a minimal change in ones daily routine.

Comparison of AHPG with Ethanol Production

Using current technologies, a relatively fit individual can produce about 200 watts of electricity sustained over time. If the standard workday consists of 9 hours (where for every hour of physical labor they rested for 30 minutes) they would produce an average 1.2 kilowatts per workday.

To help explain the viability of Active Human Power Generation let us discuss for a moment corn based ethanol production. On average for every bushel of corn that is used to make ethanol we receive 2.6 gallons of ethanol. (Bothast) 2.6 gallons of ethanol is equal to about 208,000 btu's of energy, while a bushel of corn contained about 390,376.00 BTU's of energy. (Oakridge National Laboratory-Pen State College of Agricultural Science-Suber) In other words when you produce ethanol you get about 53% of the energy from the corn into the ethanol. Ethanol is currently used as a fuel for motor vehicles that on average are 21% efficient. (Wikipedia) That means of the 208,000 btu's in 2.6 gallons of ethanol the engine actually turns 43,680 btu's into motion or 11% of the energy originally in the corn. This amount expressed in kw-h is about 13kw-h.

Now as I mentioned before a person working a 9-hour day with 3 hours of breaks mixed into the day would be able to produce about 1.2 kw-h each work day. The caloric need of this individual for the entire 24-hour period would be around 5,400 kilocalories. (Macintosh) One bushel of corn contains about 98,430 kilocalories. (Pen State College of Agricultural Science) In other words a bushel of corn would be able to allow a person to produce 1.2 kw-h every day for about 18 days. For a grand total of 21.6 kw.

In other words if active human power generation was to take the place of corn based ethanol production in the US we would produce an additional 8 kw-h of energy per bushel.

In 2008 about 32% of corn grown in the untied states was used to produce ethanol. (Bremner) Which means that the total estimated amount of energy we will receive from our ethanol endeavors is equivalent to 51,038,204,677.57kw-hours of energy. While if that same corn had been used in AHPG we would have generated about 85,653,486,775.82kw-h of energy, while giving employment and food to some 577,305 people for a year.

TABLES

The data contained in the following tables are for reference only and come from the sources in the bibliography. These are estimates based on the sources available to me and should be considered as such.

1. 23 poorest countries average hourly wage $.58/hour

52weeks per year * 40 hours per week= 2,080 hours	$1,200 per year / 2,080 hours= .576 dollars per hour

2. Random Numbers

	2008
Corn Produced (Bushels)	12,000,000,000.00
Average price per Bushel	4.80
Bushels used in ethanol production	3,840,000,000.00
BTU in 1 lb of corn	6,971.00
Lbs per bushel of corn	56.00
BTU per bushel of corn	390,376.00
Kcal/btu	0.25
Kcal/Bushel	98,438.93
Average persons weight in kg	68.00
Kcal needs of a body per day per kg	35.00
Total Kcal needed for daily life	2,380.00
Kcal need /hr	99.17
Kcal/Kg/Hr used during fast cycling	8.50
AHPG average work day	6.00
Total Kcal needed for average work day	3,468.00
Kcal/Kg/hr needed for resting between exertions	148.75
Hours of resting during work day	3.00
Total Kcal needed for HPG worker per day	5,401.75
Average in shape person generates kw/Kg/Hr	3.00
Total watts	204.00
Total watts per work day	1,224.00
Days of work per bushel	18.22
Watts per bushel	22,305.60
Kw-h per bushel	22.31
Price per watt (If AHPG had produced them with no wages calculated)	0.22

Total KW available from 2008 Harvest	85,653,486,775.82
Market Value of AHPG Electricity from Ethanol corn	9,824,454,933.19
Market Value of Total Corn used in Ethanol	18,432,000,000.00
Total Loss between market prices	-8,607,545,066.81357
Gallons of Ethanol per Bushel	2.65
BTU per Gallon of Ethanol	80000
Average efficiency of motor vehicle	0.21
BTU per gallon Actually Usable as Energy in motor vehicle	16800
KW per gallon of Ethanol via Car engines	4.920913884
Average energy efficiency of electric generator	0.42
BTU acutely converted into energy in electric generators	33600
Kw per Gallon of Ethanol via electric generator	9.841827768
KW per bushel Car	13.04042179
KW per Bushel Generator	26.08084359
Today price per gallon of ethanol	1.5
Today price per bushel of corn based ethanol	3.975
Price per gallon in 2008	3.09
Price per bushel or corn based ethanol	8.1885
Price per Kw car	0.627932143
Price per kw generator	0.313966071
Today price per kw car	0.304821429
Today price per kw generator	0.152410714
Total gallons of ethanol produced in 2008	10,176,000,000.00

Total market value of ethanol in 2008	31,443,840,000.00
Gross profit of ethanol (Market Value of Ethanol minus the cost per Bushel)	13,011,840,000.00