Abstract: Energy storage technology is the bottleneck preventing the wide adoption of alternative energy. The need to switch to renewable energy sources is great as supplies of fossil fuels continue to dwindle. Current technologies for energy storage are not adequate for large scale energy storage; new technologies are needed. This paper gives a brief overview of past, and current, methods for energy storage, as well as an introduction to some of the more novel concepts for future energy storage technologies.
I. Introduction

Humanity is facing an energy crisis. The Earth's reserves of fossil fuels are dwindling at ever-increasing rates, and the demand for energy is growing as the human population grows. Alternative energy sources are available, but the majority of them produce power intermittently and with fluctuations in the amount of power generated. The current technology used for energy storage is not designed for use with these fluctuating energy sources and is not sufficient to meet our energy storage needs. In order to adopt sustainable, renewable, efficient energy sources we need to develop sustainable, renewable, efficient energy storage technologies. It is the purpose of this paper to introduce a few of the more novel ideas for future energy storage.

II. Clean energy and the problem of clean energy storage.

The Earth's deposits of fossil fuels, which powered the rise of our current civilization, are dwindling. In order for civilization to continue in its present form, or for it to progress beyond its current state, there is a need of new energy sources. The most optimistic estimates point to a lack of the majority of fossil fuel sources within a few hundred years. The less optimistic estimates paint a grimmer picture, one in which humanity has decades worth of fuel at best. The need for alternative energy sources, renewable and sustainable ones, is a fact that is being recognized by more and more people every day. The acceptance and adoption of alternative energy technologies can be seen in the prevalence of residential solar panels and hybrid cars, wind farms and biodiesel. But with the acceptance of these alternative sources of energy comes the problem of energy storage.

Most traditional forms of energy, from fossil fuels to hydropower, are generated at a fairly constant rate. In contrast, most of the renewable, sustainable, alternative energy sources have intermittent energy outputs. Our grid is built for an energy supply constant in both power and delivery. Energy sources such as solar or wind vary considerably in intensity and duration. These vagaries in power can fluctuate in temporal cycles that are daily, seasonal, or a mixture of both. Energy input may be very strong during one time span and non-existent in the next. In order to utilize the excess energy, and in so doing, make up for the periodic lack, the energy must be stored. Current technologies are not up to the task of long term energy storage on large scales. In order to meet the majority of humanity's energy needs with alternative sources, smarter, more efficient, long-lived energy storage technologies must be developed and adopted.

A few of these novel energy storage technologies are already in development, some are just concepts, and some are a return to more old-fashioned techniques.

I.1. Traditional energy storage systems

Before any discussion on new energy storage technologies, it is prudent to discuss the current state of technologies that are in common usage, as well as those that have been used
extensively in the past. What follows is a brief overview of “traditional” methods of energy storage.

For approximately ten thousand years, since the development of agriculture, humans have stored the sun’s energy in the form of livestock and grain. Plants converted the sun’s energy into sugars in the photosynthetic process and these sugars were stored in the plant; a process which continues today. Grain, with the stored solar energy, was stored by humans and its energy released in the winter months when the calories were needed most. Likewise, livestock would eat the plants and store the solar energy in the form of fat. Humans would once again use this stored energy when it was needed.

Another ancient form of energy storage was the use of biofuels. Traditional biofuels were mainly in the form of wood, but the oils from plants and from some animals were used for heat and light as well. It was not until after the enlightenment that refined biofuels were used in any more meaningful way¹.

One traditional form of energy storage that is still in use today is the practice of pumping water uphill, usually with wind power, and storing it there until it is needed for irrigation or for energy production¹. As this method was discussed in detail in Dr. Tom’s course, this paper will not discuss pumped water storage in any greater detail.

The most common forms of energy storage technology in use today are chemical batteries. There are many differing types of chemical/metal batteries with a wide range of efficiency and uses. These storage devices are not designed for long term use, deep discharge cycles, or with intermittent energy sources¹. As with pumping water, these methods were discussed in Dr. Tom’s course and will not be discussed in depth.

I.2. Possible future energy storage systems

There are many new technologies, or concepts thereof, that could possibly fulfill civilization’s future energy storage needs. Many of the more common and promising technologies have been discussed in great detail, so much so that many members of the lay public are quite familiar with these concepts. Hydrogen fuel cells, new chemical/metal batteries, and compressed air are examples of these common concepts¹.² This paper will not discuss these technologies in any more detail. Instead, the discussion will focus on a few novel energy storage systems not commonly discussed.

There are two general categories of novel energy storage technologies discussed in this paper. The first category is a return to a very ancient energy storage system with a modern twist; the use of biological-based storage media, such as biodiesel and ethanol production from novel sources. The second category contains a unique mechanical concept for energy storage, the Gravity Battery.
Biological-based energy storage is not an answer to the problem of capturing electrical energy from alternative sources and storing it for later use. The real promise of these technologies comes from waste utilization and integration with the existing energy production systems. By harnessing the sun’s energy with plants and animals, which are then turned into liquid fuels, society can utilize a natural, efficient energy storage system. The energy is stored as lipids or sugars and can be released, after being converted into fuel, by combustion. This can power traditional generators and supply constant electricity to the power grid.

Algae-based biofuels are promising sources for energy storage\textsuperscript{5,6}. Algae can be grown on sewage effluent and helps remove many of the excess nutrients therein\textsuperscript{5}. An example of what an algae production system looks like can be seen in figure 1. As can be seen in figure 2, algae production plants can be connected in tandem with industrial smokestacks in order to utilize the CO\textsubscript{2} emissions for improved algal growth\textsuperscript{5}. High lipid stains of algae can be grown and produce fuels ranging from biodiesel to jet fuel\textsuperscript{5,6}.

The larvae of *Hermetia illucens*, shown in figure 3, commonly called the black soldier fly, are comprised of approximately 30\% lipid\textsuperscript{7}. These fly larvae thrive on manure, sewage sludge, and food processing byproducts at rates close to 3 kg/m\textsuperscript{2} per day\textsuperscript{8}. Researchers have successfully processed these organisms into biodiesel with results acceptable by industry standards\textsuperscript{7}. These organisms could be a great adjunct to an energy production system that turns industrial and municipal wastes into biofuels. Coupled with algae production, rearing of black soldier flies could help make waste into a resource, as well as capture excess carbon and nutrients before they pollute the environment.

One last organism that is noteworthy in its potential for energy storage is the hemp plant. Hemp, *Cannabis sativa* (figure 4), is a plant that produces an oil-rich seed\textsuperscript{9}. The oil is edible and has a high market value, but is damaged by high heat\textsuperscript{10}. As a byproduct of edible oil extraction, inedible oil can be released from the spent seeds by heating them and pressing them further\textsuperscript{9,10}. This inedible oil is ideal for biodiesel production and the finished product meets industry standards\textsuperscript{10}.

The gravity battery concept is just that, a concept which has not been put into practice at this time\textsuperscript{11}. The idea can be found at www.gravitybattery.info, and the premise is illustrated in figure 5 of this paper. The basic operation of the gravity battery is: Weights attached to long cables are suspended in drilled holes in the ground. The cables are attached to a generator that can be used as a spindle for the cables. Energy from wind, wave, or solar sources winds the spindles up when excess energy is being produced. When the stored energy is needed the cables are allowed to unravel turning the generator. The generator produces energy from the stored potential energy of the weighted cables. This is an interesting concept, one I would be excited to see tested. The major flaw I noticed in the concept is the initial cost of the drilling. The up-front cost could prohibit the wide acceptance of this technology.
III. Summary & Conclusion

In summary, the need for new energy storage technologies is great. Whether solar energy is harvested via a biological agent (algae, insects, or plants) or by chemical and mechanical methods (Gravity Battery), development of energy storage technologies should be a top priority around the globe. If civilization as we know it is to continue or advance, new ways of harnessing and storing energy are needed. A few concepts were presented in this paper, some of which address other pressing issues (waste management) in addition to energy storage. Perhaps one or more of these technologies will be further developed and widely accepted.
References


Figures & Figure Captions

Figure 1. Example of algae production system
Figure 2. Schematic diagram of the sequestering of CO$_2$ by algae production

Coal Power Plant - Tiered Vertical Wafered Algae System

Collection and Redirection Piping

Smoke Stack

CO$_2$

O$_2$ Output

Bio-Fuel Output

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Figure 3. Life stages of *H. illucens*
Figure 4. Hemp, *C. sativa*
Figure 5. The Gravity Battery concept

THE GRAVITY BATTERY CONCEPT

- Rechargeable
- Environmentally friendly
- Teams design multiple tasks
- Maintains its safety
- Available on location
- Maintenance free
- 100% safe
- Small footprint

ABOVE THE GROUND
(A) SOLAR PANEL ARRAY
Generates energy from sunlight entering the wall.

(B) DISTRIBUTOR
When there is energy surplus or when it is consumed, the distributor sends surplus energy to the battery charger.

(C) BYPASS LINE
Provides energy directly to the household whenever needed, such as to maintain electricity.

(D) ALLOCATOR
 memoria of the stored energy demands of the household satisfied, to allocating energy from the sun and/or from the battery.

BELOW THE GROUND
- HOW IT WORKS
- A solar panel, which contains a cylinder underground with a weight attached, will rotate if the weight is heavier than the sun. 
- As the sun rises, the weight pulls the cylinder up, generating electricity. 
- When energy is needed, the weight is released to the ground, restoring the cylinder to its original position.
- A battery is charged up, its weight is at the maximum height and it is attached to the generator unit, resulting in energy storage.

- GRavity BATTERIES
- A battery operates on the principle of energy storage and conversion. 
- The battery is charged up, its weight is at the maximum height and it is attached to the generator unit, resulting in energy storage.
- When energy is needed, the weight is released to the ground, restoring the cylinder to its original position.

- Generator & CPU
- The generator converts the energy from the battery into electrical power. 
- The CPU controls the flow of energy to the household.

- PROJECT
- The project is focused on the concept of the gravity battery and how it can be implemented in real-world scenarios.

WANT TO KNOW MORE?
Visit our website for more information and to share your comments and ideas. Read what others have to say about the gravity battery, or visit if you are interested in learning more about this exciting technology.