adaptiveARC and the Future of the Energy Industry

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Introduction

Since the beginning, humanity has been dependent on some type of energy source to survive. Dating back to the first humans that walked the Earth, energy was used to hunt and gather food. Human population was extremely low and the Earth was able to provide a plentiful amount of nourishment, leading to a relatively easy and low expenditure of energy. As humans continued to evolve and become more intelligent, they discovered agriculture, one of our greatest achievements still to this day.

With the invention of agriculture humans were able to create surpluses of food that resulted in a major population boom. Humans no longer had to rely on nature to provide food; they could manipulate different types of crops and grow the type of food they deemed necessary.

Along with crop agriculture came the domestication of animals. Once humans had domesticated and trained animals to assist in farming practices, agricultural production exploded and the population followed closely behind. While animals were being domesticated, humans also began to burn firewood for another crucial source of energy. The use of animals in farming coupled with fire was the first time in history that energy was put into the production process that did not come directly from human expenditure.

It was not until the Industrial Revolution occurred in the 18th century that a new more powerful and efficient energy source was needed. Luckily, “the English found that coal could produce a fuel that burned cleaner and hotter than wood charcoal” (US EIA, web). Even though coal produced a lot more energy than animals or wood burning, it was very hard to extract from the ground. Newer machines were invented that could be more efficient at
mining the coal and humans again had changed the way that they used energy. Unfortunately, this great discovery also sparked a trend that continues to be a problem for humans today, the heavy emission of carbon dioxide (CO₂) and other greenhouse gases (GHG).

Skipping a head to the 20th and 21st centuries as oil begins to run scarce and excessive coal burning contributes heavily to the rise in GHG emissions, humans have been forced to begin to search for alternative forms of energy that are more abundant and cause less pollution. Oil has now become our leading source of energy and is consumed at a rate of about 40 Quadrillion BTUs per year (Table 1) (EPA Resource Conservation and Recovery, web).

Table 1. US energy consumption by energy source

<table>
<thead>
<tr>
<th>(Quadrillion Btu)</th>
<th>Energy Source</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>98.208</td>
<td>100.350</td>
<td>100.486</td>
<td>99.843</td>
<td>101.545</td>
<td></td>
</tr>
<tr>
<td>Fossil Fuels</td>
<td>84.078</td>
<td>85.830</td>
<td>85.817</td>
<td>84.657</td>
<td>86.212</td>
<td></td>
</tr>
<tr>
<td>Coal</td>
<td>22.321</td>
<td>22.466</td>
<td>22.797</td>
<td>22.447</td>
<td>22.776</td>
<td></td>
</tr>
<tr>
<td>Coal Coke Net Imports</td>
<td>0.050</td>
<td>0.137</td>
<td>0.045</td>
<td>0.061</td>
<td>0.025</td>
<td></td>
</tr>
<tr>
<td>Natural Gas¹</td>
<td>22.897</td>
<td>22.931</td>
<td>22.583</td>
<td>22.191</td>
<td>23.637</td>
<td></td>
</tr>
<tr>
<td>Petroleum²</td>
<td>38.809</td>
<td>40.294</td>
<td>40.393</td>
<td>39.958</td>
<td>39.773</td>
<td></td>
</tr>
<tr>
<td>Electricity Net Imports</td>
<td>0.022</td>
<td>0.039</td>
<td>0.084</td>
<td>0.063</td>
<td>0.106</td>
<td></td>
</tr>
<tr>
<td>Nuclear Electric Power</td>
<td>7.959</td>
<td>8.222</td>
<td>8.160</td>
<td>8.214</td>
<td>8.415</td>
<td></td>
</tr>
<tr>
<td>Biomass³</td>
<td>2.817</td>
<td>3.024</td>
<td>3.134</td>
<td>3.361</td>
<td>3.596</td>
<td></td>
</tr>
<tr>
<td>Biofuels</td>
<td>0.414</td>
<td>0.513</td>
<td>0.595</td>
<td>0.795</td>
<td>1.024</td>
<td></td>
</tr>
<tr>
<td>Waste</td>
<td>0.401</td>
<td>0.389</td>
<td>0.403</td>
<td>0.414</td>
<td>0.430</td>
<td></td>
</tr>
<tr>
<td>Wood Derived Fuels</td>
<td>2.002</td>
<td>2.121</td>
<td>2.136</td>
<td>2.152</td>
<td>2.142</td>
<td></td>
</tr>
<tr>
<td>Geothermal Energy</td>
<td>0.331</td>
<td>0.341</td>
<td>0.343</td>
<td>0.343</td>
<td>0.349</td>
<td></td>
</tr>
<tr>
<td>Hydroelectric Conventional</td>
<td>2.825</td>
<td>2.690</td>
<td>2.703</td>
<td>2.869</td>
<td>2.446</td>
<td></td>
</tr>
<tr>
<td>Solar/PV Energy</td>
<td>0.064</td>
<td>0.064</td>
<td>0.066</td>
<td>0.072</td>
<td>0.081</td>
<td></td>
</tr>
<tr>
<td>Wind Energy</td>
<td>0.115</td>
<td>0.142</td>
<td>0.178</td>
<td>0.264</td>
<td>0.341</td>
<td></td>
</tr>
</tbody>
</table>

¹Includes supplemental gaseous fuels.
²Petroleum products supplied, including natural gas plant liquids and crude oil burned as fuel.
³Biomass includes: biofuels, waste (landfill gas, MSW biogenic, and other biomass), wood and wood derived fuels.
PV = Photovoltaic.

Notes: Data revisions are discussed in the Highlights section.
Totals may not equal sum of components due to independent rounding.
Sources: Non-renewable energy: Energy Information Administration (EIA), Monthly Energy Review (MER) December 2008, DOE/EIA-0035 (2008/12) (Washington, DC, December 2008,) Tables 1.3, 1.4a and 1.4b; Renewable Energy: Table 1.2 of this report.
With the exception of 2006, this table indicates that US energy consumption has been experiencing a steady rise and shows no signs of slowing down. However, the United States is not the only nation that is increasing their annual consumption of energy; globally, marketable energy is being consumed at a faster rate with each passing year. The United States Energy Information Administration (US EIA) published a report titled *International Energy Outlook 2009* (IEO 2009) about the current global usage of energy and also included projections for the future. The IEO 2009 predicts that by 2030, we will be consuming 678 quadrillion BTUs per year which is a 44% increase over the fifty year period from 1980 to 2030 (Table 2) (EIA IEO 2009, web).

**Table 2. World Marketed Energy Consumption**
The report also states that countries, such as the US, France, and the UK, that are members of the Organization for Economic Cooperation and Development (OECD) are responsible for a majority of the global energy consumption because of their well established economies and industrial markets. Oil is predicted to remain at a relatively high cost and will continue to be the slowest growing source of energy as we continue into the future. Luckily, due to increased global awareness about the dangers of global warming and heavy CO₂ emissions, renewable energies are predicted to see a 3% increase per year (Table 3) (EIA IEO 2009, web).

**Table 3. World Electricity Generation by Fuel**

![Figure 16. World Electricity Generation by Fuel, 2006-2030](image)
As our population gets closer to 7 billion people, larger sources of energy are needed now more than ever. Finding a solution to this problem continues to be difficult as the negative effects of global warming and climate change continue to snowball because of increased GHG emissions. When our oil reserves dry up, where will we get the power needed to sustain our planet’s massive demand for energy and ever growing population while taking the problem of climate change into consideration?

As one of the most advanced countries in the world, it is imperative that the United States continues to be a front-runner in the improvement of renewable energies such as biomass, biofuels, hydropower, wind power, solar power, and waste conversion to set a good example for other countries. Luckily, adaptiveARC, a startup company that was founded in February 2008 in Carlsbad, California is dedicated to the improvement of the planet’s current energy use problem and committed to finding a realistic solution (Benetton and Heida, p. 4). In this paper, I intend to analyze adaptiveARC’s unique product and innovative strategy at creating an almost entirely new source of alternative energy. I also intend to relate this product and strategy to large and small-scale sustainable lifestyles and discuss how they may change our way of living.

**adaptiveARC**

As mentioned previously, adaptiveARC was founded in 2008 with the aspiration to revolutionize the renewable and alternative energy sector. adaptiveARC is a waste-to-energy (WTE) based company that uses a new type of gasifier to convert solid waste into energy. This very complicated process is made possible by adaptiveARC’s groundbreaking Cool Plasma Arc Gasification™ (PAG) technology (adaptiveARC, web). “adaptiveARC’s gasification plants cleanly and efficiently convert biomass, agricultural, municipal, coal, and
even toxic waste into clean energy such as electricity, biofuels and hydrogen for fuel cells” (adaptiveARC, web). With the PAG technology, adaptiveARC’s smallest scale plant is capable of producing between 0.5 and 1.0 MW/h per ton of waste (Benetton and Heida, p. 7) that is put into the system.

This new cutting edge technology is so valuable because it can also process non-organic forms of waste and has almost no polluting emissions. When waste is placed into the reactor, it is heated to temperatures as high as 5,500°F or 3,000°C (adaptiveARC); at this point the waste is broken down into elemental components in a gaseous form, then separated into individual atoms. Once all the materials are broken down, 95% are converted to syngas (Benetton and Heida, 7) and the other 5% turned into an inert fly ash. The syngas contains high amounts of carbon monoxide and hydrogen that are sent through a generator where they are converted into electrical energy and can be fed back into the electrical grid. The bi-product of the adaptiveARC reactor, inert ash, is also economically valuable to the company. The inert ash can be sold as a construction material to help pave roads, lay down asphalt, or produce concrete. Surprisingly, “on a volumetric basis, the facility will generate approximately 1 truck of ash for every 125 trucks of waste coming into the plant” (adaptiveARC, web).

Not only does adaptiveARC provide an excellent solution to alternative energy but they also offer different reactor sizes to accommodate different types of application. The smallest scale reactor is the SB2000 and is the basis for the Industrial-Class size plant (Figure 1) (adaptiveARC, web).
The Industrial-Class is recommended by adaptiveARC for small landfill managers, demolition projects, hotels, agriculture, and other industries of that size. It also offers a 95% reduction in waste and modularized design for easy expansion. The return on investment (ROI) periods for the 5 different Industrial Class reactors is reasonable too, less than 7 years (Table 2) (adaptiveARC, web).

**Table 4. Industrial Class ROI**

<table>
<thead>
<tr>
<th>Product</th>
<th>Tons per day</th>
<th># days to repay</th>
<th># years to repay</th>
</tr>
</thead>
<tbody>
<tr>
<td>I1</td>
<td>100</td>
<td>2,536</td>
<td>6.95</td>
</tr>
<tr>
<td>I2</td>
<td>200</td>
<td>1,721</td>
<td>4.72</td>
</tr>
<tr>
<td>I3</td>
<td>400</td>
<td>1,313</td>
<td>3.60</td>
</tr>
<tr>
<td>I4</td>
<td>600</td>
<td>1,177</td>
<td>3.23</td>
</tr>
<tr>
<td>I5</td>
<td>800</td>
<td>1,109</td>
<td>3.04</td>
</tr>
</tbody>
</table>

The next size up is the SB6000 reactor and is the foundation for the Urban-Class plants (Figure 2) (adaptiveARC, web).
The Urban-Class reactor fits in with scenarios such as multi-year construction or demolition projects, waste management companies, local governments, or the military. Just like the Industrial Class, it reduces 95% of waste and has a modular design along with an ROI of less than 7 years for its 4 different configurations (Table 3) (adaptiveARC, web).

**Table 5. Urban Class ROI**

<table>
<thead>
<tr>
<th>Product</th>
<th>Tons per day</th>
<th># days to repay</th>
<th># years to repay</th>
</tr>
</thead>
<tbody>
<tr>
<td>U1</td>
<td>254</td>
<td>2,536</td>
<td>6.95</td>
</tr>
<tr>
<td>U2</td>
<td>1,016</td>
<td>1,721</td>
<td>4.72</td>
</tr>
<tr>
<td>U3</td>
<td>1,524</td>
<td>1,313</td>
<td>3.60</td>
</tr>
<tr>
<td>U4</td>
<td>2,032</td>
<td>1,177</td>
<td>3.23</td>
</tr>
</tbody>
</table>

The last reactor type offered by adaptiveARC is the SB24000 and provides the foundation for the Metropolitan-Class plant (Figure 3) (adaptiveARC, web).
The Metropolitan-Class plant works best with large landfill managers, county, state, and federal agencies, and large military operations. This large-scale reactor is best used for heavy volume waste reduction. Just like the 2 smaller reactors the Metropolitan Class also has a very good ROI (Table 4) (adaptiveARC, web).

Table 6. Metropolitan Class ROI

<table>
<thead>
<tr>
<th>Product</th>
<th>Tons per day</th>
<th># days to repay</th>
<th># years to repay</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>1,000</td>
<td>2,536</td>
<td>6.95</td>
</tr>
<tr>
<td>M2</td>
<td>2,000</td>
<td>1,721</td>
<td>4.72</td>
</tr>
<tr>
<td>M3</td>
<td>3,000</td>
<td>1,313</td>
<td>3.60</td>
</tr>
<tr>
<td>M4</td>
<td>4,000</td>
<td>1,177</td>
<td>3.23</td>
</tr>
<tr>
<td>M5</td>
<td>6,000</td>
<td>1,109</td>
<td>3.04</td>
</tr>
<tr>
<td>M6</td>
<td>9,000</td>
<td>1,109</td>
<td>3.04</td>
</tr>
</tbody>
</table>
**adaptiveARC’s Potential for Waste Reduction**

In 2008, the United States Environmental Protection Agency (EPA) reported that the US generated 249,610,000 tons of materials in the municipal waste stream (MWS) (US EPA, web) and that only 82,870,000 tons, or 33% (US EPA, web) was recovered. Energy recovery from waste, or WTE, refers to the creation of energy in the form of electricity or heat from the incineration of materials from the MWS (US EIA, web). Most of these processes use municipal solid waste (MSW) to produce this energy through combustion or can produce a combustible fuel such as methanol (US EIA, web). The EPA defines municipal solid waste as:

- materials from municipal sources, sent to municipal landfills… MSW includes product packaging, bottles and cans, food scraps, consumer electronics, and tires… grouped into durable/nondurable goods, containers and packaging, food scraps and yard trimmings, and miscellaneous inorganic wastes.

Paper and cardboard materials are the number one contributors to the MWS by far but it is the different types of metals that we dump in our landfills that pose a big problem. Not only do these materials affect the landfill they sit in, but they also pollute our groundwater, cause atmospheric pollution and over load the underground carbon sink. The two big questions these facts give rise to are, what kinds of effects do overflowing landfills have on our climate and where will we continue to put our waste as population increases and the number of available landfills decreases?

It is a commonly known fact that Earth is going through a period of warming and most believe that anthropogenic activity is at least partly responsible. Local and global temperatures are experiencing a rise that is most closely related to an increase in greenhouse
gas concentrations in the atmosphere, “CO$_2$ is about 30% higher and methane 130% higher than at any time. And the rates of increase are absolutely exceptional: for CO$_2$, 200 times faster than at any time in the last 650,000 years” (Dow and Downing, p. 34). The EPA’s report titled, *Greenhouse Gas Emissions From Management of Selected Materials in Municipal Solid Waste* (p. 4), states that there are four main processes associated with landfills that cause an increase in GHG concentrations:

(1) Energy consumption associated with making, transporting, using, and disposing the product or material that becomes waste.

(2) Non-energy related manufacturing emissions, such as the CO$_2$ released when limestone is converted to lime.

(3) CH$_4$ emissions from landfills where the waste is disposed.

(4) CO$_2$ and nitrous oxide (N$_2$O) emissions from waste combustion.

The EPA has implemented programs like Waste Wise, a large-scale effort in recycling, reusing, and reducing garbage, in an attempt to combat these negative effects but all have been unsuccessful in increasing the amount of MSW converted back into energy (US EPA, web). Where these attempts fail, adaptiveARC has the potential to succeed and revolutionize the entire waste industry with their unique PAG technology and scalable reactor sizes.

As landfills continue to be shut down or become too full to hold any more MSW, a reasonable and economically viable solution must be presented soon. adaptiveARC has the ability to use this growing problem to their advantage and be a major player in the battle against severe climate change and global warming. Not only will the need for landfills decrease, but large concentrations of unnecessary GHG will be taken out of the atmosphere also. These two major breakthroughs would create a trickle down effect starting with overall
global improvement and continue all the way to the individual level. If we pair the United States’ smallest contributor to the total MWS, rubber and leather, along with the data previously mentioned, the smallest plant produces anywhere from 0.5 to 1.0 MW/h per ton of waste, an astounding calculation can be made to show how much energy could be created by one adaptiveARC plant.

- Use the average of the energy production potential = 0.75 MW/h per ton of waste
- Calculate the amount of rubber and leather put into MWS per day =
  \[(7,410,000 \text{ tons/1 yr})(1\text{yr}/365 \text{ days}) = 20,301 \text{ tons per day}\]

\[-(0.75\text{MW/h per ton of waste}) \times (20,301 \text{ tons/day}) = 15,226 \text{ MW/h produced per day}\]

Because 15,226 MW/h or 15,226,000 kW/h is an inconceivable amount of energy to comprehend, it will be much easier to think of this number on a large scale. To put matters in perspective, in 2008, according to the United States Energy Information Administration, California’s industrial sector consumed approximately 1,833 kW/h per month on average. In principle, that means that if the amount of rubber and leather generated in the MWS in one day in 2008 was run through adaptiveARC’s smallest reactor, all of California’s industrial sector could be powered for almost 23 years! The EPA’s report, *Municipal Solid Waste Generation, Recycling, and Disposal in the United States Detailed Tables and Figures for 2008* states that the United States is only using 12.6% of the MWS for combustion with energy recovery (Figure 4) (US EPA, p. 4) but hopefully adaptiveARC can soon change that.
Eye opening statistics like these need to be taken into consideration on a large scale as adaptiveARC continues to finalize and market its product. Once adaptiveARC gains enough traction and credibility in its industry, the potential to completely change the face of energy production will become a reality. Currently, adaptiveARC is conducting an operational trial using their small-scale reactor in Modesto, California. After the initial trials are completed and raw data collected, the system will be shipped to Mexico to begin converting 25 metric tons of MSW per day into energy for the local community. adaptiveARC is hoping to use the results from the system running in Mexico as an example for their phenomenal product and begin selling and installing units all over America and eventually worldwide.

adaptiveARC also has the ability to make vast improvements on a small scale. If the industrial sized class plant were installed on a college campus, for example Cal Poly, a noticeable improvement would be observed almost immediately. The use of an adaptiveARC plant at Cal Poly would result in two significant changes. The first of these changes would be
a large decrease in the necessity for a waste disposal plan. Because of adaptiveARC’s versatility, all types of waste, agricultural, paper, plastics, metals, etc. could be collected and used for the production of copious amounts of energy. Not only could Cal Poly’s waste be used, but also the city of San Luis Obispo could strike a deal with the university to dispose of some of their waste. This point brings me to the second significant change, financial gain. During this time of economic crisis, every dollar that can be saved is extremely valuable. If Cal Poly installed an adaptiveARC unit, the university would be able to sustain itself by creating its own energy and eventually sell excess energy back into the grid to reach their ROI. Along with the sale of excess energy, all of the local cities, San Luis Obispo, Pismo Beach, Arroyo Grande, etc. could pay Cal Poly to use the adaptiveARC plant in exchange for the energy produced. If successful, Cal Poly could become an energy powerhouse on the central coast and possibly California while setting a perfect example for others to follow.

Conclusions

Considering the current state of our climate, it is almost impossible to deny that climate changes worldwide are being caused by human activity and that measures must be taken to slow or stop them. If something is not done soon, future generations could face severe consequences. The Intergovernmental Panel on Climate Change (IPCC) has made it very clear that “human impacts, increased greenhouse gas concentrations in particular, appear to be responsible for the major climate changes of recent decades” (Kump and Mann, 19). As our population continues to increase at a rapid rate its negative effects will only continue to get worse. More specifically, GHG emissions will reach dangerous levels, landfills will continue to overflow, and climates will change profoundly. Human civilization has continued to survive and evolve because of our ability to adapt to changing conditions and utilize
different sources of energy. As it stands now, we are using our most valuable non-renewable resources at such a fast pace that they are in danger of being completely depleted. Research and development of alternative forms of energy must be discovered and utilized as soon as possible to help conserve non-renewable energies.

adaptiveARC is a company that is on the brink of establishing itself as a leader in the entire energy production industry. Innovative technology and several different sized reactor models allow them to have a very broad market base and attract different types of consumers. The idea of turning waste that most people consider useless into large quantities of readily available energy is not new but adaptiveARC has taken it to the next level. Not only are their reactors highly efficient but the sole by product, inert fly ash, can also be sold to construction companies for a profit.

The time has come for mankind to stop our irresponsible use of current natural resources and take the future into consideration. As a planet, we are nearing the point of no return as far as non-renewable energy sources are concerned and something must be done. adaptiveARC has begun to revolutionize the energy production industry and hopefully in the near future, will be one of our nation’s biggest providers. The establishment of adaptiveARC will not only reduce the amount of waste going to landfills and reclaim some of the GHG emitted into the atmosphere but will also bring an improvement to the personal, social, and environmental aspects of our lives.
Works Cited


