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ENERGY SECURITY THROUGH WILD DIATOMIC MICROALGAE CULTIVATION IN LATIN AMERICA

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Dependence on petroleum imports from a small clique of potentially unfriendly and unstable countries jeopardizes U.S. security by granting these nations unprecedented political leverage, draining U.S. financial resources, and funding international terrorism. U.S. alternative fuel policy has centered on the use of corn ethanol, a highly inefficient and costly biofuel. This brief proposes that the United States instead encourage wild diatomic microalgae cultivation in Latin American through a pilot program in Panama. Wild algae have high oil content, are easily cultivated, place little strain on fresh water resources and arable land, and cleanse water of pollutants. By developing a wide algae supplier base in the Americas, the United States can contribute to regional economic development and environmental quality while moving in the direction of energy security.

The Dangers of Oil Dependence

The United States' heavy dependence on petroleum imports from a small number of authoritarian and politically unstable suppliers leaves the economy vulnerable to price spikes and funds anti-American activity.

Reliance on Imported Energy

- In 2009, the United States imported approximately half of its needed petroleum with OPEC nations providing by far the largest percentage of imports at 48%.[1]

- The U.S. spent an average of $272 billion per year between 2005 and 2009 on oil imports,[2] accounting for approximately 17% of its total imports.[3]

- Persian Gulf nations control 64% of world oil supplies, while Venezuela, Nigeria, and Mexico control an additional 11%.[4]

Economic Vulnerability

- Oil market disruptions impact both U.S. price levels and price volatility.[5] A negative supply shock of 7 million barrels per day would lead to a nearly 3% decrease in U.S. GDP.[6]

- Every $10 increase in per barrel cost of oil raises Department of Defense energy costs by more than $1.3 billion.[7]

Funding Anti-American Activities

- Venezuela's Hugo Chavez and Iran's Mahmoud Ahmedinejad have directly linked their nations' oil abundance to an ability to block U.S. foreign policy goals.[8]

- Since the late 1980's, Saudi Arabia's semi-official charities sent over $70 billion, largely raised from oil revenues, to spread Wahhabist Islamic doctrine abroad by establishing mosques, schools, and Islamic centers that create a support network for radical terrorists.[9]

Criteria for Achieving Energy Security

Energy security for the United States rests on having as many suppliers for our energy needs as possible. As the number of U.S. energy suppliers grows, competition holds down the price of energy, opponents see less opportunity to manipulate energy dependence as a coercive tool, and political instability within supplying nations carries less weight for the U.S. economy.

To achieve long-term energy security, the United States should encourage:

- A diversified supplier base that lessens dependence on one group of states for energy needs.

- A sustainable and reliable renewable fuel source that will provide long-term energy security as excess demand for petroleum depletes global oil reserves.

Current Biofuel Policy: Corn Ethanol

U.S. biofuel policy heavily relies on the production of corn ethanol, which constituted 7% of the U.S. fuel market in 2008.[10] While congress seeks to increase biofuel production from the current 12 billion gallons per year to 36 billion gallons per year by 2022,[11] relying on corn ethanol to provide this increase will encourage reliance on an unsustainable, inefficient and costly biofuel.

Inefficiency of Corn Ethanol

Due to corn's poor photosynthetic efficiency, corn ethanol fuel is incapable of satisfying U.S. energy needs.

- Corn ethanol has a low net energy balance, producing only 25% more energy than used in its production.[12]

- Even if current biofuel crops, including those used for both ethanol and biodiesel, covered all arable land across the world, the resulting oil would supply less than half of global energy needs.[13] Producing enough corn ethanol to meet even half of current U.S. energy needs would require over eight times the U.S.'s current cropland.

Economic Costs of Ethanol

The use of corn as a biofuel crop places upward pressure on food prices, triggering social unrest, trade barriers, and increased hunger and malnutrition for the world's poor.

- Global cereal prices have more than doubled since 2000;[14] increased biofuel production triggered between 10% and 33% of this price rise.[15]

- Rising food prices caused worldwide protests, such as those in Mexico, Italy, China, and Pakistan in 2007-2008.[16]

- As domestic food prices rise, agricultural exporters such as Russia and Argentina have limited or blocked exports, causing further scarcity and rising prices.[17]

- According to the World Bank, doubling food prices decreases caloric intake among the global poor by 20%, a potentially life-threatening reduction for many.

The Promise of Algae in Latin America: Panama as a Test Case

For long-term energy security, the United States should encourage algae biofuel production globally – particularly in Latin America. Wild diatomaceous algae can sustainably produce a large amount of fuel oil and can be cultivated throughout the Americas as a local energy source, a water purification system, and a potential export crop. Widespread production of algae fuel will significantly lower energy prices, lessen the oil producers' cartel power, and offer a promising renewable fuel source.

- *Algae's High Energy Efficiency*: Marine algae have a net energy balance 15 to 300 times that of corn ethanol and can produce 5,000 to 15,000 gallons of oil per acre annually. Even at a conservative estimate, algae yield approximately 278 times as much energy as corn ethanol.[18] Technological advances could further boost this already impressive yield.[19]

- *Cultivation*: To minimize costs, cultivation would center on wild diatomaceous microalgae, which can be sustainably cultivated at relatively low cost in pre-existing brackish lakes and ponds. Central America's warm, sunny climate proves ideal for rapid algae growth and frequent harvests, allowing a high volume of production.

Pilot Program in Panama

In order to develop and test a cultivation model, the United States should promote a pilot program in Panama. The nation's stable political climate, pre-existing transport infrastructure, and favorable geography qualify it as an excellent test site for algae development to provide a model that other Central American nations could adopt with minor modifications.

Why Latin America?

- *Favorable Geography and Climate*: Central America and the northern part of South America enjoy a warm tropical climate with high levels of sunshine and rainfall and relatively consistent year round temperatures. This environment favors rapid year-round algae growth with a harvesting cycle of under ten days, allowing very high yields.[20] Also, since nearly 30% of South America lies within 62 miles of the coast, the region has relatively high access to non-potable salt water for algae growth.

- *Proximity to the United States*: The region's geographic proximity to the United States enhances the sustainability and lowers the cost of exported algae fuel. Reducing the expense, fuel consumption, and air pollution involved in transport would enhance algae fuel's cost-competitiveness with petroleum and reduce the environmental damage associated with extensive transport.

Why Panama?

- *Political Stability*: Panama stands out as a stable Central American nation, with relatively high per capita GDP and relatively low crime rates for the region. Poverty rates have fallen by 10% since 2002, while economic growth was 7% in 2010.[21] Panama has seen five successive civilian elections, and retains close economic and political ties with the United States.

- *Transport Infrastructure*: For algae fuel exports to be economically viable, pre-existing transport infrastructure must exist within the producing nation. The Panama Canal, which is currently undergoing expansions that will double its capacity,[22] provides an ideal gateway for export for the entire hemisphere. Since 77% of the economy rests on service industries, most of which revolve around the Panama Canal, transport infrastructure and services within the nation are highly developed.[23]

Algal Production Techniques

Many species of algae hold promise for fuel production. Diatomic microalgae hold particular advantages as the fastest-reproducing species on earth with an oil production rate of 45.6 tons of oil/hectare/year.[24] Cultivating wild algae instead of a forced monoculture in pre-existing natural lakes, ponds, or man-made bodies of water would avoid much of the expense and labor involved in eliminating unwanted algae species.

- Panama's Lago Gatun, a large man-made lake with an area of about 166 mi^2 that abuts the Panama Canal,[25] provides a large, convenient test site. Even if only 15% of the lake's surface area were utilized, the lake's area is large enough to produce roughly 2.15 million barrels of biofuel per year, depending on production yields. At the largest estimate, this yield amounts to 0.14% of U.S. oil imports from OPEC nations in 2009.[26]

- Estimated operating costs of open-pond algae cultivation run about $3.1 million per square mile.[27] Assuming a 15% cultivation rate for Lago Gatun, the cost of cultivating algae would run $77 million at the highest. However, the actual figure would likely be considerably lower, since this model calculates costs based on maintaining a monoculture. By cultivating pre-existing wild algae instead, growers would eliminate maintenance costs associated with herbicides and other treatments to eliminate unwanted species.[28]

- To cultivate diatomaceous microalgae within Lago Gatun, producers would suspend an algal turf scrubber covered with nylon netting on which algae would grow. Necessary inputs include CO2, nitrogen, and phosphorous. Since these elements can be obtained from polluted or waste water, algae prove an excellent water filtration and carbon sequestration mechanism.[29]

- Once removed, the algae would be channeled through on-site refineries to produce usable fuel. Although costs for algae refineries remain highly variable, standard biodiesel refineries run about $25 million.[30]

- The lake's location along the Panama Canal would allow easy transport of algae biofuel throughout the nation and the entire hemisphere.

The Benefits of Algae in the Americas

Fulfills Energy Security Requirements

Because algae thrive in a wide variety of environments, widespread production across Latin America would reduce the leverage of oil-supplying nations and provide a sustainable long-term fuel source.

- *Diverse Production Base*: Eleven nations in Central and South America, including Honduras, El Salvador, Nicaragua, Costa Rica, Panama, Belize, Venezuela, Guyana, Suriname, Brazil, and the coast of Colombia possess the 20˚-30˚C temperature range ideal for year-round high-yield algae cultivation.[31] With such widespread production potential, no state in Latin America, or globally, would likely dominate the algae market as Saudi Arabia dominates the petroleum market.

- *Algae's Sustainability*:

  - Algae grow in salt or wastewater and thrive in virtually any warm location. As a result, algae production does not place greater strain on scarce arable land or fresh water sources.

  - Aside from minerals such as nitrogen and phosphorous already present in contaminated water, wild algae requires no fertilizer or chemical inputs.

  - Because algae feed on a combination of carbon dioxide and nitrogen dioxide, they remove CO2 from the air in a process known as "carbon capture." Growing algae near factories with high air pollution rates could significantly improve local air quality.[32]

  - Algae are a renewable, fast growing, and energy rich biofuel crop whose production can be scaled to meet global energy demands.

Local Water Purification

- Algae remove heavy metals from contaminated water. When supplemented with sand screens to remove water-borne bacteria and parasites, algae could provide an inexpensive, sustainable water filtration system for remote villages without clean water infrastructure.

- South American nations have notoriously poor water quality, with 77 million citizens lacking access to clean water.[33] Cultivating algae as a dual-purpose fuel source and water filtration mechanism would contribute greatly to human development within the region and increase political support for algae cultivation.

Economic Development in Latin America

- Algae for biodiesel would provide a lucrative, high-demand export crop that does not compete with the resources needed for Central America's current agricultural exports, such as coffee and tropical fruits, and would constitute a valuable and easily produced export crop.

- Algae infrastructure would provide employment and income for many the region's residents, who often survive through subsistence farming in impoverished rural areas. Operating the cultivation process would not require some training but no extensive education, allowing employment opportunities for relatively low-skill workers, while refineries would offer employment opportunities for higher-educated workers.

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