

TEAM ENGERYNEERING HERE TO CONQUER THE WORLD'S ENERGY PROBLEMS

**Team Members: Ragheb El Khaja, Abi Jain, and
anonymous students SC and TM**

CHALLENGES

- Finding a renewable energy source
- Reducing CO₂ emissions

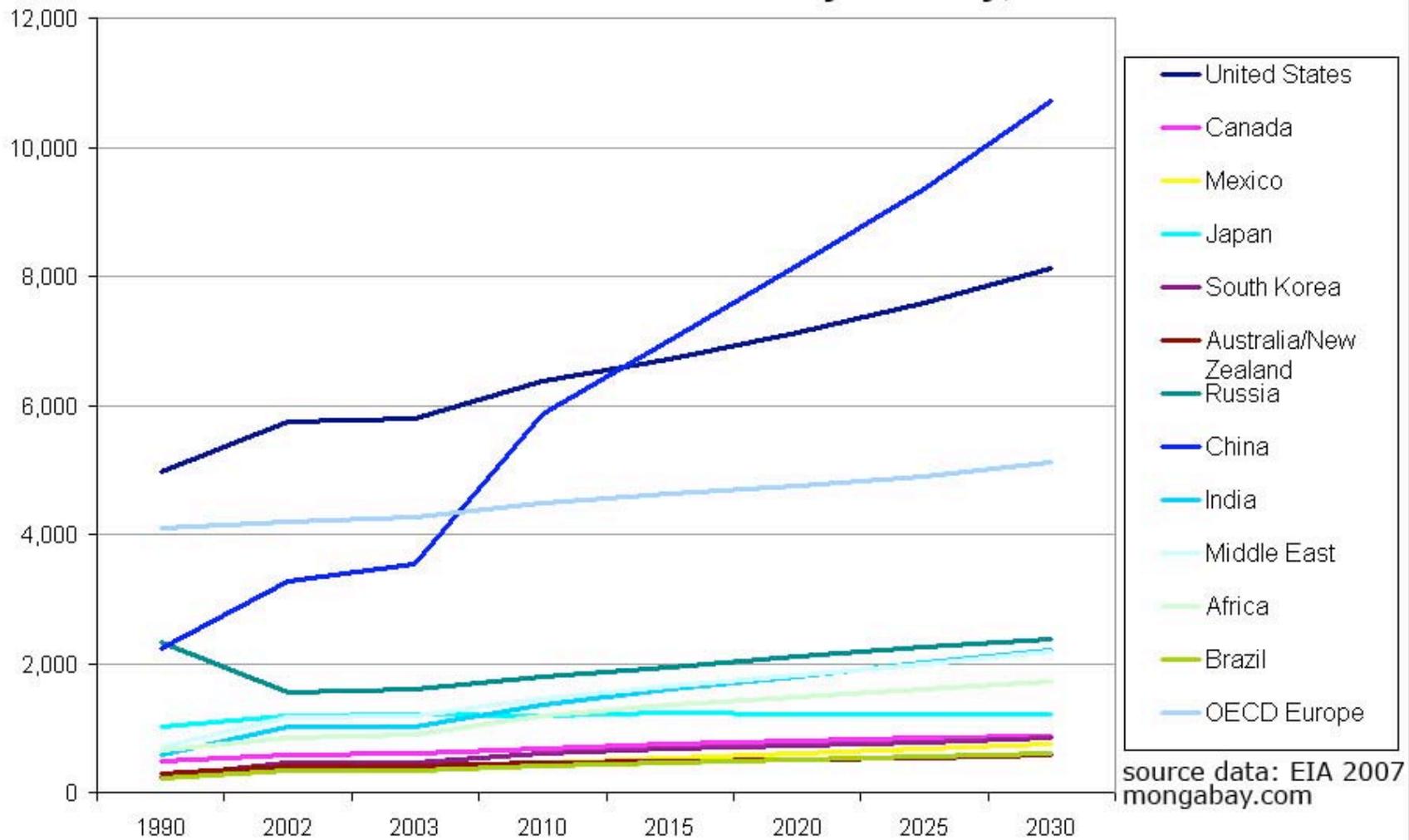


IMPORTANCE OF THIS CHALLENGE

- Reduce dependence on foreign oil
- Current energy sources are harmful to the environment
 - Their high carbon emissions cause depletion in the ozone
- Current energy sources are running out
 - According to USA Today: we're expected to use up all petroleum in 40 years



World Carbon Dioxide Emissions by Country, 1990-2030

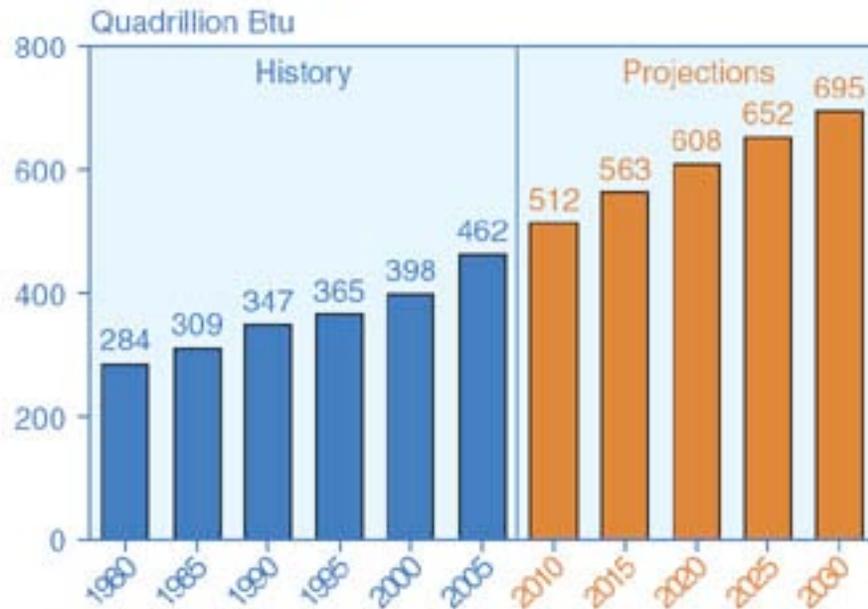


Courtesy of Mongabay. Used with permission.

http://photos.mongabay.com/07/co2_country_1990-2025.jpg



Figure 9. World Marketed Energy Consumption, 1980-2030



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2005* (June-October 2007), web site www.eia.doe.gov/iea. **Projections:** EIA, *World Energy Projections Plus* (2008).

Graph removed due to copyright restrictions.

See "Chart of US Gulf Coast product prices" 1991-2008 at <http://www.bp.com/sectiongenericarticle.do?categoryId=9023773&contentId=7044469>

<http://eia.doe.gov/oiaf/ieo/world.html>

<http://www.bp.com/sectiongenericarticle.do?categoryId=9023773&contentId=7044469>



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Graphic of energy use in the United States: energy consumption by sector and source, electricity generation sources, electricity use between generation/transmission and retail sales, and sources of petroleum imports. Data from US EIA Annual Energy Review, 2003.

<http://www.theglobaleducationproject.org/earth/energy-supply.php>



IMPACT OF SOLUTION

- Save the resources! Save the planet!
 - Have the capability to continue everyday life as it is
 - Be able to sustain our technological advance
 - Decrease the depletion of the ozone
 - Reduce geopolitical tensions over energy sources



SYNTHETIC GENOMICS TO PRODUCE BIOFUEL

- General Design Idea:
- Locate genes for hydrocarbon synthesis.
- Locate genes for photosynthetic pathways that provide greatest efficiency.
- Create an artificial chromosome making these modifications to the genome of a photosynthetic bacteria.
- Test to see if this works. If so, start focusing on applications where we make it able to function in a smokestack.



Image removed due to copyright restrictions.

Graphic of DNA sequencing for bioenergy, by Synthetic Genomics.

See -

<http://web.archive.org/web/20070703041822/http://www.syntheticgenomics.com/images/syntheticDNA-Large.jpg>



SYNTHETIC GENOMICS TO PRODUCE BIOFUEL: POSSIBLE COMPETING TECHNOLOGIES

- Existing infrastructure (unless we can make it cheaper, it won't be very feasible to implement).
- Also, algae, plants any other biofuel technologies that may or may not involve synthetic biology.
- Genetically modified microbes that use fermentation to produce hydrocarbons

Images removed due to copyright restrictions.

See Synthetic Genomics, <http://www.syntheticgenomics.com>



SYNTHETIC GENOMICS TO PRODUCE BIOFUEL: KNOWN AND UNKNOWN

- How successful would genome reengineering on this scale be?
 - We're talking about taking a photosynthetic bacteria, making its photosynthetic pathway more efficient, and at the same time taking genes for hydrocarbon synthesis and inserting them.
 - We also want these hydrocarbons to be secreted.
- Further details include perhaps implementing this technology in an industrial capture and sequestration application—i.e. in a powerplant smoke stack to take advantage of high CO₂ and at the same time reducing plant emissions.
- An unknown here would be tolerance of our microbe to those conditions—can't really modify the flue gas—the microbe has to be adapted to that environment—this might require some work with the genes from extremophiles.



ENERGY FROM CELLULOSE: THE BASIC IDEA

- Cellulose can be digested to glucose, which can be transformed to biofuels.
- Some microorganisms can digest cellulose to glucose using various cellulases.
- We plan on using such microorganisms to convert cellulose to its glucose monomers.



Photo courtesy of [Docman](#) on Flickr.

PATHWAYS

- Use recombinant DNA technology to mass produce cellulase and allow it to breakdown cellulose invitro.
- Modify Cellulase-producing bacteria to reduce its energy uptake, increase its cellulose breakdown and make it excrete the produced glucose.



SO WE HAVE GLUCOSE, WHAT NOW?

- Employ fermentation of glucose to produce bioethanol, which can be used in petrol engines.
- Modify bacteria so that it uses the glucose to produce and release hydrocarbons.



COMPETING TECHNOLOGIES

- Many companies are breaking down cellulose to glucose to bioethanol.
- Genetic Engineering is not commonly used.
- Can improve the current techniques by genetically modifying the cellulase-producing bacteria to increase efficiency.



WHAT DO WE KNOW?

- The process can and has been done without genetic engineering.
- Lots of research has been done on the microorganisms in nature that undergo cellulose hydrolysis.



UNKNOWNNS

- Efficiency of process.
- Costs.
- Necessity of pretreatment of cellulose source.



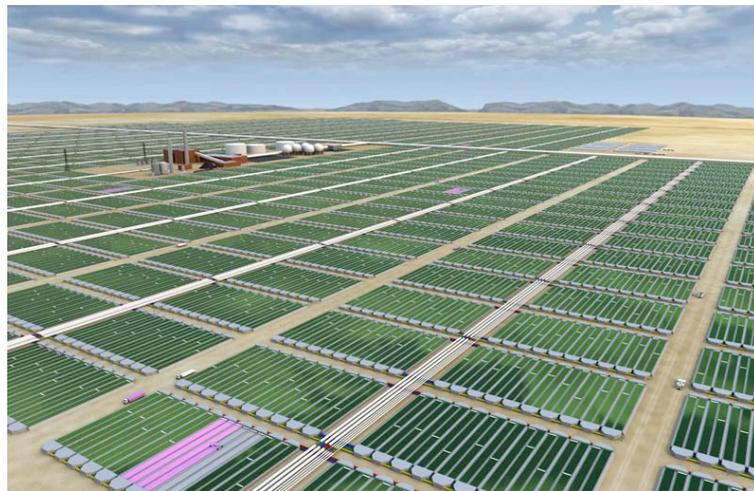
GROWING GREEN: THE BASIC IDEA

- Utilize the photosynthetic pathway by modifying algae to produce hydrocarbons, rather than glucose
 - In order to accomplish this, we must:
 - Find a way to divert the photosynthetic pathway from producing glucose to producing hydrocarbons
 - Maximize the efficiency of light absorption
 - Maximize the excretion and collection of the hydrocarbons
- Why algae?
 - Only need water, sunlight, and CO₂ to grow
 - High photosynthetic rate



GROWING GREEN: POSSIBLE COMPETING TECHNOLOGIES

- Non-bioengineering Solutions:
 - Current algae farms
 - Using corn or soybean oil as biofuels
- Other bioengineering Solutions:
 - Research at UC Berkeley to minimize the number of chlorophyll needed to harvest light
 - Companies such as Boeing are trying to use algae to produce algae biojet fuel



Courtesy of Solix Biofuels. Used with permission.

GROWING GREEN: HOW OUR IDEA IS NOVEL

- Genetically modify the algae genome by targeting the specific genes involved in photosynthesis
- Maximize the photosynthetic process by
 - 1) increasing rate of light absorption
 - 2) eliminating the need for light as the energy source
 - Use glucose as the alternative source

Photo of algae under microscope removed due to copyright restrictions.



GROWING GREEN: KNOWN AND UNKNOWN

- Excretion of hydrocarbon product
 - Will the hydrocarbons be excreted automatically?
- How much CO₂ is too much?
 - If the algae are exposed to an excess of CO₂, how much can they handle before they die
- Location and containment
 - Will they be grown in the ocean, farms, labs, bioreactors?
- How much light do our modified algae need in order to perform the reaction?
- How many rounds of photosynthesis can the modified algae undergo before dying?



SUMMARY

- What is Team ENERYneering going to do to solve today's energy problems??
- Idea 1: Synthetic Genomics to Produce Biofuel
 - Create an artificial chromosome that can create hydrocarbons through photosynthesis
- Idea 2: Energy from Cellulose
 - Genetically modify bacteria to mass produce cellulase to convert cellulose to bioethanol
- Idea 3: Growing Green
 - Modify algae to produce hydrocarbons through the photosynthetic pathway

ANY QUESTIONS???



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