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Recycling Carbon Dioxide to Make Liquid Fuels

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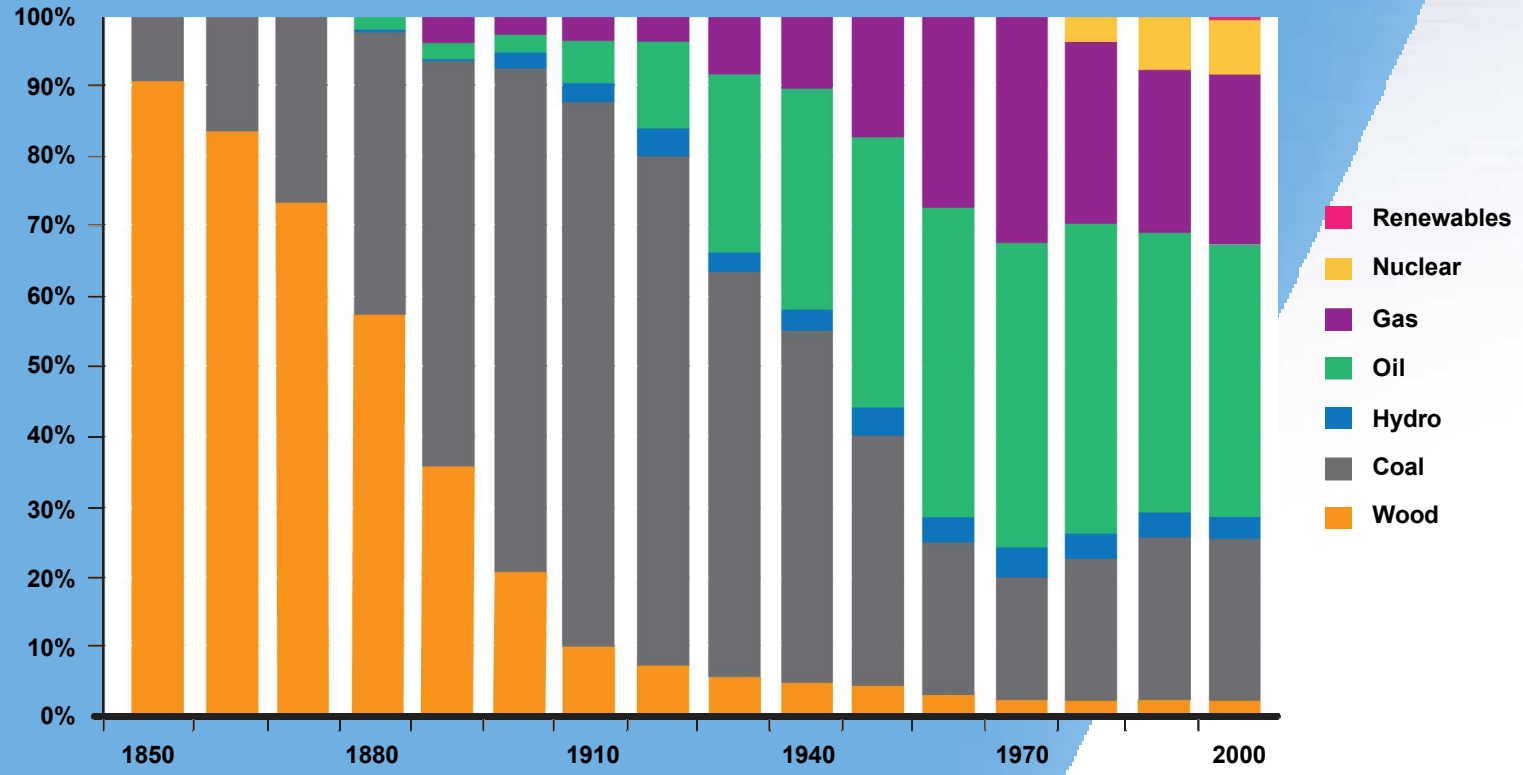
Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000.

History tells us that significant energy portfolio changes take decades.

Major Energy Transitions



Source: Energy Information Administration

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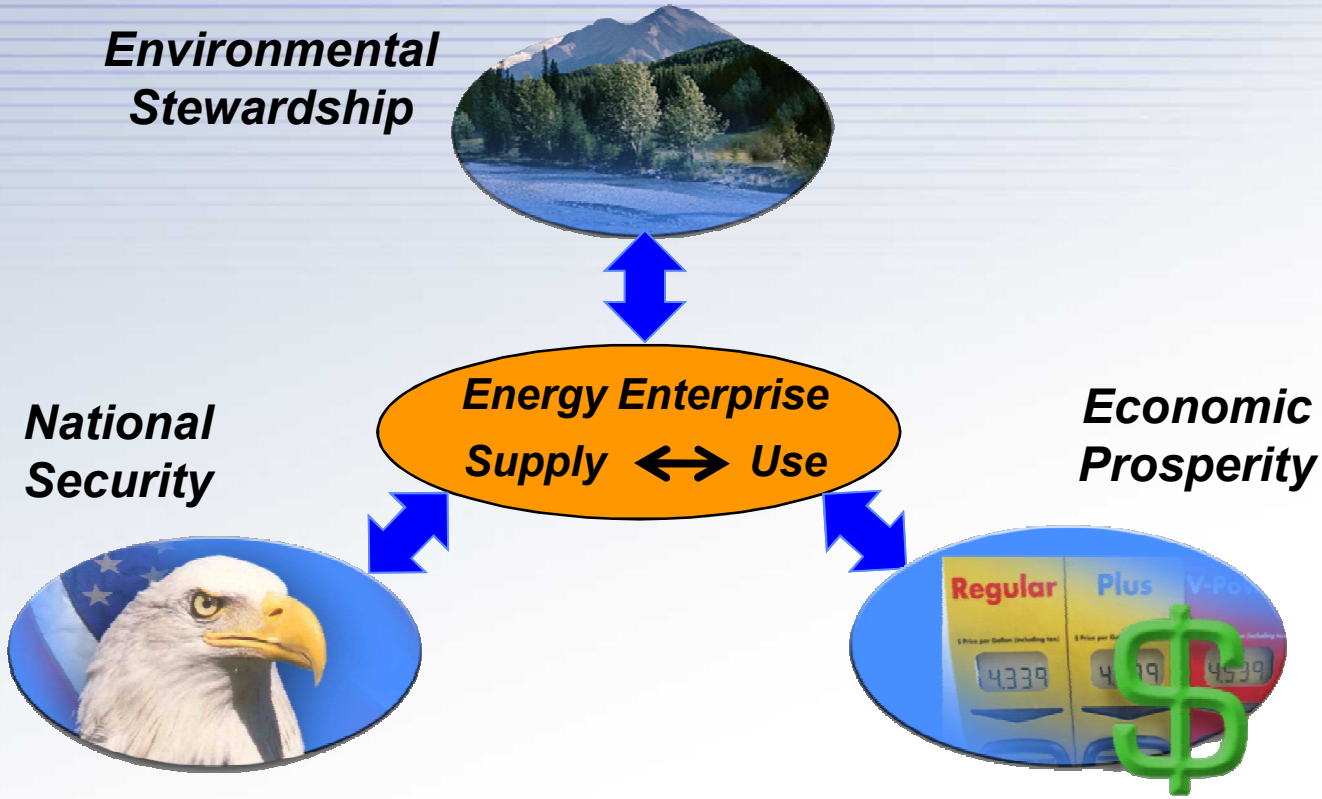
Our energy security future must consider three perspectives:



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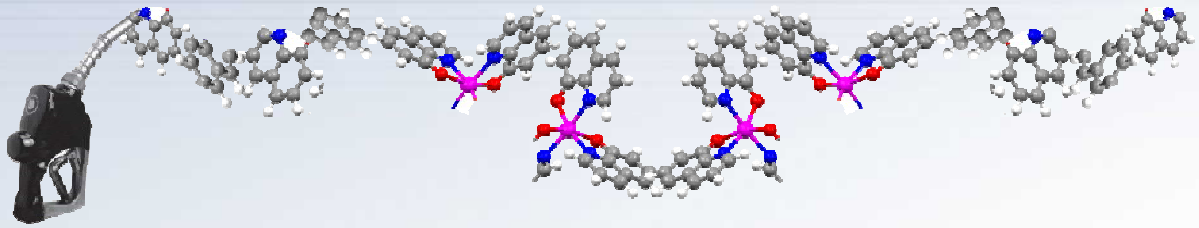
The vision for carbon dioxide-recycling fuels is to:

- Stabilize the concentration of CO_2 in the atmosphere
- Produce new supplies of liquid hydrocarbon fuels (such as gasoline, diesel, jet fuel), domestically



- A few requirements:
  - Fuels compatible with existing infrastructure
  - Scalable to millions of barrels per day
  - Economically attractive

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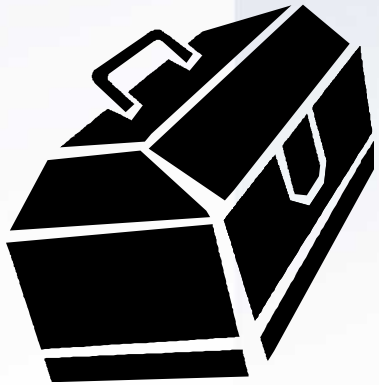
It seems prudent to prepare our carbon management toolbox.

- Each barrel of oil combusted produces 0.42 metric tons of CO_2
- U.S. used 21 million barrels of oil per day in 2007 and each year
- In the U.S., the transportation sector contributes almost 2 Gt of CO_2 to the atmosphere annually
- Pharmaceuticals, food, chemical, oil recovery, electronics, fire suppression industries - less than 0.2 Gt annually



Reduce

Extract

Reuse

Recycle

Store

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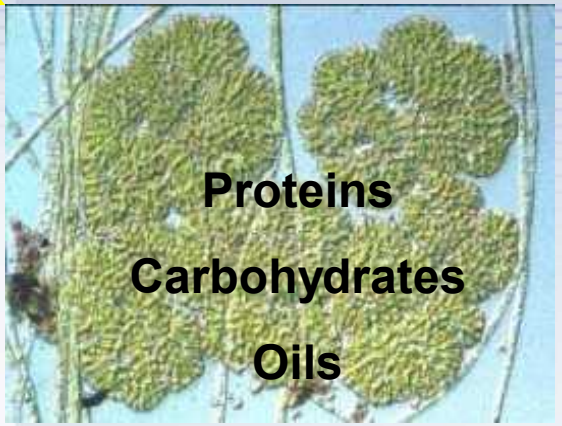
Biofuels rely on photosynthesis to make proteins, carbohydrates, and "oils."

Sunlight

CO_2

H_2O



Microalgae have been studied as a source of biofuels for 50 years

- Originally to derive methane from wastewater treatment
- Early 70's: hydrogen
- Early 80's: "bio-oil" (biodiesel)
- US: $50M invested in pre-genomic Aquatic Species Program from 1980-1995 (NREL)
- Japan: $500M spent on CO_2 Abatement Program from 1990-2000

Microalgae Has Some Unique Advantages

- Grows with impaired water (brackish, municipal waste water)
- Greater photosynthetic efficiency than in higher terrestrial plants (10 x)
- Algal biocrude is suitable as a feedstock for existing US refining capacity

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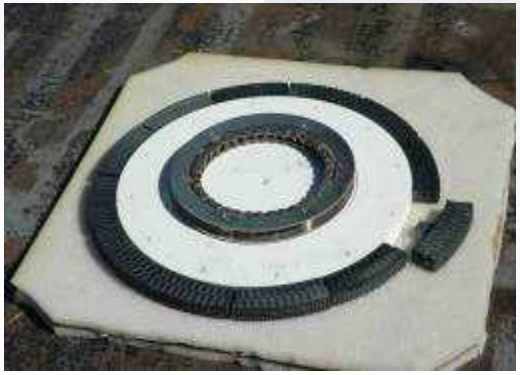
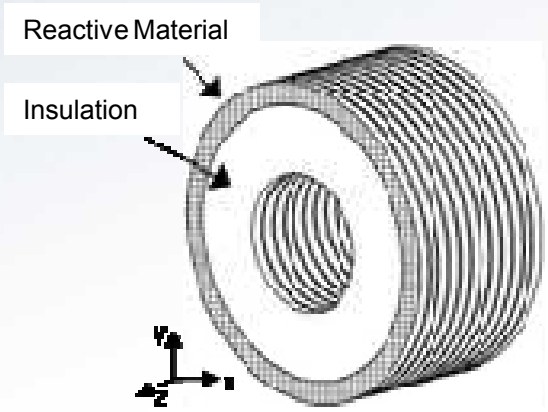
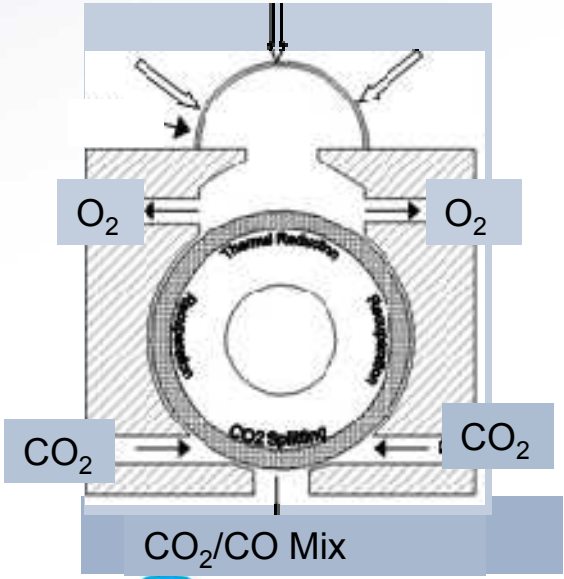
"Sunshine to Petrol" uses the sun's energy to break apart CO_2

Concentrated Solar Flux







Counter-Rotating-Ring Receiver/Reactor/Recuperator

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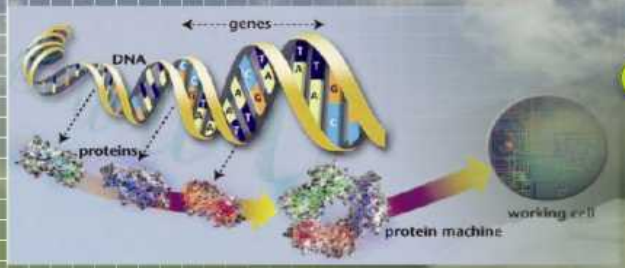
"Tomorrow's Energy Today"

RECYCLING CO_2

carbon management options

CO_2, H_2O



algal biofuels

sunshine to petrol

stored energy

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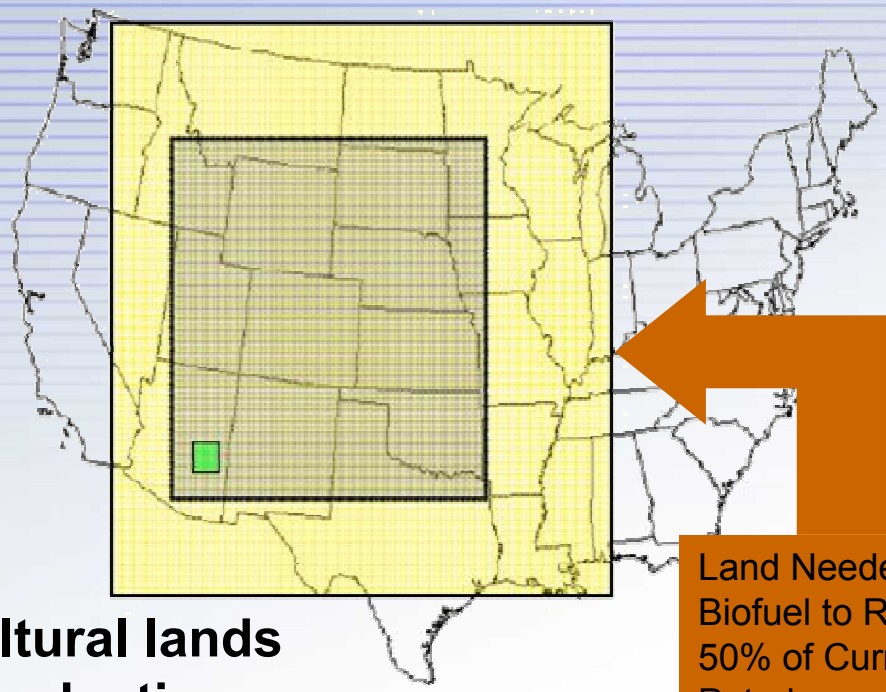
SUPPLEMENTAL INFORMATION

The Promise of Algae-Based Biofuels

Gallons of Oil per Acre per Year	
Corn	~ 20
Soybeans	~ 50
Safflower	~ 80
Sunflower	~ 100
Rapeseed	~ 125
Oil Palm	~ 635
Micro Algae	~ 1000 – 7000



Land Needed for Biofuel to Replace 50% of Current Petroleum Diesel using oil from:
Corn
Soybean
Algae

- Need not compete with agricultural lands and water for food and feed production
- Effectively captures and uses CO_2
- Can use non-fresh water… Avoids fresh water depletion
- Can potentially reduce deforestation (Science, 2008)
- Produces higher energy-content fuels
- Higher photosynthetic efficiency than terrestrial energy crop

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