

Energy and Global Warming

A problem for society

A presentation by

Richard S. (Dick) Stein

University of Massachusetts

Amherst

<stein@ecs.umass.edu>

Where does energy come from?

It originally arises from the **hydrogen** fusion reactions occurring on the sun.



The **energy** is radiated and a small fraction reaches the earth. This causes photosynthesis leading to the growth of **plants**. Over millions of years, these are converted to oil and coal. **We are burning this and using up this energy rapidly!**

What's the Problem?

- We have been dependent upon fossil fuels (oil, coal, natural gas) for energy.
- These were formed from vegetation which stored the collected energy of the sun for millions of years.
- We are using this energy at an increasing rate, and we will soon run out.
- The principal consumers of energy have been the “first world” countries (U.S., Europe, Japan).
- Many “third world” countries (China, India) are rapidly developing and will use energy at an increasing rate.

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What to do?

- Use energy at a lower rate. **CONSERVE!** (hybrid cars, public transportation, better insulation, heat pumps, change in lifestyle).
- Use available energy sources in a better way. (gasification of coal, synthetic oil).
- Develop alternate energy sources:
 - Biofuels
 - Solar heating
 - Solar cells
 - Wind
 - Hydro and tidal
 - Geothermal
 - Nuclear

NOTE: With the exception of nuclear, all of these sources are getting their energy from the **SUN**.

Some approaches -

- Some are **political** and **societal**, while others are **technical**.
- Some can be accomplished **rapidly**, whereas others may take **many years** to accomplish.
- Some can be accomplished through **individual efforts**, whereas others may require **political action**.

CONSERVATION -

- The U.S. uses about **2X** as much energy/capita than many European countries and **10X** as much as many Asian and African ones.
- **Conservation** can be accomplished rather rapidly by individual actions.
- This may involve housing, lighting, transportation, and agriculture and could cut our energy use by **half** or more.

SOME EXAMPLES -

Savings around the house -

A typical American single family home is responsible for more than 11 metric tons of carbon dioxide emissions every year through its energy use.

Where to save -

- Heating and air conditioning
- Appliances
- Insulation
- Water heating
- Lighting

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Lighting - about 20% of energy

Incandescent Lamps

10-20% efficient

Compact Fluorescent

70 - 90%

Light Emitting Diode (LED)

90 - 95%

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Is there enough energy coming from the sun?

YES - More than enough!

The amount of the sun's energy falling on the earth in one minute is more than we use in one year.

We are using it **VERY** inefficiently. We must learn to do better.

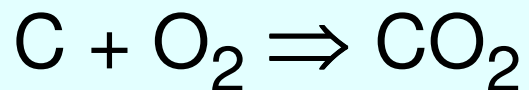
How can we convert the sun's energy into something we can use in an economical way?

We've been using the sun's energy for many years by burning coal and oil.

We (and China, *et al*) have enough coal to last for a century or two.

SOME PROBLEMS:

- Coal is not a suitable fuel for mobile vehicles.
- They produce carbon dioxide (CO₂) when burned which is a greenhouse gas leading to global warming.



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Consequences:

As a result of this change in the atmosphere, a greater fraction of the infrared radiation will be reflected back to earth, leading to an increase in its average temperature

Use of coal for fuel for mobile vehicles

It is possible to convert coal to a gaseous or liquid fuel. Means for doing this were explored during the Gulf War crisis but were mostly abandoned because of cost,

HOWEVER: Oil will become more scarce and expensive. Such efforts will be revived.

A PROBLEM: This approach usually results in producing more CO₂ than if the coal or oil was used directly.

What to do with the CO₂?

□ **CAPTURE** and store or sequester it.

- Pump it into caverns or oil wells. Will these be stale for long periods of time?
- Pump it into the sea. How will it affect coral, marine life?
- React it with things that will bind it as a stable compound. Carbon nanotubes - COST?

□ **USE** it to make some stable products.

- Currently used for dry cleaning and as a processing aid in plastic fabrication.
- “Synthetic Photosynthesis” - to be discussed

The Future:

As industrialization continues, if fossil fuel remains as a principle energy source, further **global warming** is likely, with consequent environmental effects.

THIS SUGGESTS the need for alternatives to fossil fuels as energy sources.

NATURE *has used sunlight to make coal and oil - but*

It took **millions of years**. Can we do better?

BIOFUELS: Nature did it by growing ferns, etc. which got converted to coal and oil by heat and pressure.

Can we find plants that grow faster and which we can convert to fuel?

- Corn - US midwest
- Sugar cane - Brazil
- Switchgrass
- Wood - New England?

An advantage of Biofuels - They are “carbon dioxide neutral”

The CO₂ evolved when they are burned is balanced by that absorbed during their synthesis when the plants grow.

PHOTOSYNTHESIS:

CO₂ + water + sunlight \Rightarrow sugars, starch, cellulose

The energy of the sunlight is stored in these organic compounds which may be used directly or converted into fuels. **This results in no net change in atmospheric CO₂.**

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Some problems with biofuels

- ❑ They require much land for their growth. There is probably not enough available.
- ❑ The use of agricultural products for fuel competes with their use for food. Feedstock for cows for dairy farmers has tripled in price during the past year.
- ❑ Their cultivation requires fuel for tractors, fertilizer, and transportation of products. The economics is marginal.
- ❑ They must be used in a way that does not harm the environment. No smoke or pollutants.

A SOLUTION: Use additional agricultural products such as corn stalks and waste wood. This often requires new technology.

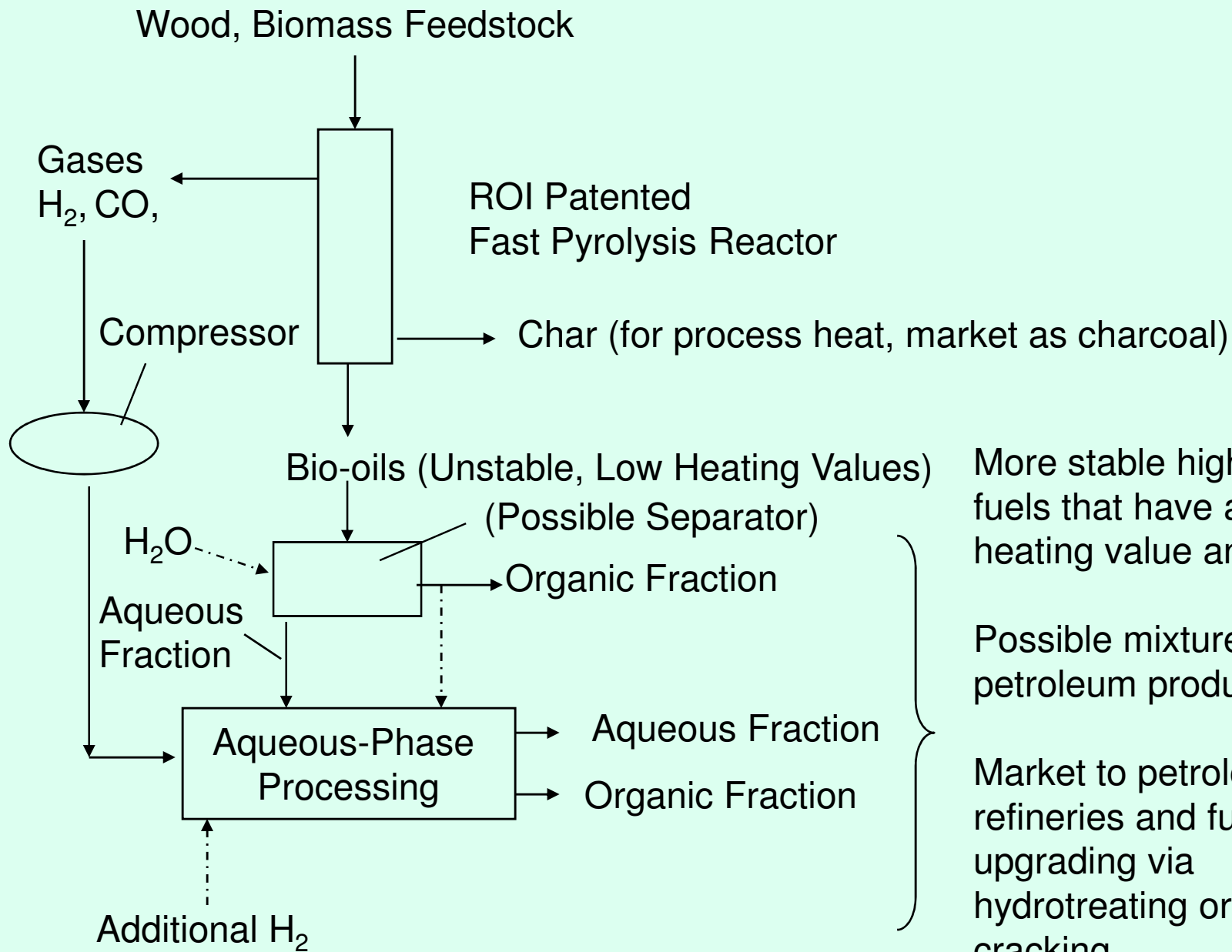
Some examples -

- ❑ The campus of Mt. Waschusetz Community College in Gardner, MA is primarily heated by waste wood from sawmills. The effluent is cleaned and meets strict air standards, There is excess capacity which will be used to generate electricity.
- ❑ A group at UMass, Amherst is working with a company in Alabama developing portable “fast pyrolysis” which can be placed in the woods to form “bio-oil” containing much of the energy in the wood. The hope is to convert this into oil for heating and mobile fuel.

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The US Department of Energy (DOE) and the US Department of Agriculture (USDA) estimated that by 2030, the US could sustainably produce 1.3 billion metric tons of dry biomass/year consisting of cellulosic biomass. This amount of biomass has the energy content of 3.8 billion BOE (barrels of oil energy equivalent), and the US consumes 7 billion barrels of oil/year. In the US it has been estimated that the cost of cellulosic biomass is \$5 to \$15/BOE, which is significantly below the current cost of crude oil of \$56/bbl (average cost in 2005). However we do not as yet possess the technology to economically convert plant biomass to liquid fuels. One of the most promising methods for conversion of biomass into liquid fuels is fast pyrolysis.



More stable high value fuels that have a higher heating value and stability.

Possible mixtures with petroleum products or

Market to petroleum refineries and further upgrading via hydrotreating or catalytic cracking.

Another thought -

In **photosynthesis**, we are capturing the energy of the sun by having it do some chemistry, and then obtaining energy by using the products as fuel. Could we take a **SHORT CUT** and eliminate the chemistry step? Might we use the light directly to give us energy?

That is what is done in a photovoltaic or **SOLAR CELL**. These have been made in the laboratory with efficiencies better than 20% and commercial ones are available with about 5% efficiency. They are used for special applications such as for watches, emergency phones, etc. They are currently too expensive for most energy generation applications. However, they will become better be more expensive, so **they have a future!**

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What about cars?

About 1/4 - 1/3 of the energy used in the U.S. is for powering automobiles. What can we do to reduce this?

Conservation

- Better mileage standards
- Public transportation
- Life styles

Diesels (Biodiesels) - more efficient than gasoline

Hybrids

- Diesel hybrids
- Plug hybrids
- Diesel plug-in hybrids
- Fuel cell plug-in hybrids

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Why are hybrids better?

They are driven by electric motors which receive their energy from batteries. These are charged by a generator driven by a much smaller gasoline engine than required by a usual car which is not needed for short distance driving. Thus, there is saving of fuel.

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The Electricity Fiend Occasional electric power wasn't enough for Ron Gremban, a Marin County electrical engineer. In leading an effort by CalCars, a small nonprofit dedicated to such technology, Gremban added 260 pounds' worth of lead-acid batteries and channeled the extra juice into the car's propulsion system. His car can now run on electricity at up to 34 miles per hour for 10 miles. It works so well that the car's technology may soon be incorporated into the limited production of such "plug-in hybrids." Which makes Gremban feel a bit like Henry Ford.

Nuclear Power

There are two kinds of nuclear power, **fission** and **fusion**.

In **FISSION**, the nucleus of an atom such as that of uranium or plutonium splits apart into two lighter atoms along with the emission of neutrons.

In **FUSION**, atoms of hydrogen, or its isotopes, are brought together to produce helium atoms.

In both cases, there is a loss in mass, Δm , which leads to the production of a large amount of energy, ΔE , according to the equation of Einstein:

$$\Delta E = \Delta m c^2$$

where c is the velocity of light, 3×10^{10} cm/sec

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Problems with nuclear fission -

- ❑ Concern with safety. Worries about a meltdown like Three Mile Island or Chernobyl. Engineers say this concern has been addressed.
- ❑ Disposal of radioactive used fuel. No acceptable solution has yet been found.
- ❑ Economic reality suggests that the REAL cost may not be competitive if costs of mining uranium, processing, and decommissioning are considered.
- ❑ Concern that future supplies of uranium may not be adequate. These could be avoided if spent fuel is reprocessed, but this involves security concerns.

An Alternative - FUSION

Rather than **fission** of heavy atoms like uranium or plutonium, one carries out **fusion** of light atoms like hydrogen and its isotopes. This also results in a loss of mass and liberation of large amounts of energy.

This is the source of the sun's energy.

The atoms must collide with great force. This occurs on the sun because of its high temperature. On earth, what can one use as a container?

On the sun, the large mass leads to high gravity which holds them together.

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The status of fusion -

- ❑ Efforts to achieve fusion have been carried out for over 50 years without success, so far.
- ❑ The problem is to drive the atoms together with sufficient velocity and to contain them. Attempts to do so involve:
 - Opposing high energy lasers
 - “Magnetic bottles”
- ❑ So far the energy necessary to do it exceeds that obtained.
- ❑ There is an intense world-wide effort to solve the problem.
- ❑ **MY GUESS**: It will eventually be successful, but it will take a long time - perhaps 20 - 30 years.
- ❑ **IF SUCCESSFUL**: It would be a solution to the energy problem.
- ❑ **IT'S A GAMBLE** but, I think, worth the effort!

An Opinion:

- ❑ While nuclear energy has problems, technology advances will ultimately lead to its being safe,**
- ❑ It is presently not economically competitive for many countries, but as fossil fuel becomes more scarce and expensive, it will become so.**
- ❑ It has the potential of being a source of greater amounts of energy than is presently obtainable from all sources.**

What to do?

- Nuclear energy may become safe and acceptable. There is uncertainty. If so, it will probably take appreciable time to develop systems and infrastructure.**
- Meanwhile, it seems wise to develop alternate energy sources.**
- No one of these will suffice. The balance will depend on location.**