

Only during the last 6 lifetimes (~62 yrs ea.) did masses of men ever see a printed word; the last 4 has it been possible to measure time with any precision; the last 2 has anyone used an electric motor; and the majority of the goods we use today have been developed within the present lifetime.

Alvin Toffler
1970

TOWARD A BLACK-GOLD STANDARD

Hard Decisions Now,
Harder Decisions Later

GROUND RULES AND CAVEATS

- Your servant is neither an economist, an ecologist, a physicist nor a political theorist
- Nor has he ever had a strictly original thought
- (He is, however, a hypocrite)
- His job is to make you
 - Question your scientific assumptions;
 - Think in *systems* in addition to *processes*;
 - Get angry, but get along;
 - Synthesize and synergize;
 - Any one or more of the above
- Let's make each other successful!

PITCH THE CYNICISM

- Our mission touches both science and politics
- Let's keep 'em separate as long as we can
 - Science: diagnose challenges, offer solutions
 - Politics: select from the suite of options/solutions
- Let's not be deterred by:
 - Fear of "guilt by association" with politically unpopular ideas, their proponents or their implications
 - Disputes over minutiae
 - Concerns over immediate practicality or cost

ONE LAST, FIRST THING

- I assume that we can design/engineer systems to accomplish just about anything worthwhile to an arbitrary degree of reliability
- Atsumi's \$170 cubic watermelon and lettuce marketed by the leaf are a staggering illustration of the power of ingenuity

THE DREAM

An American beef industry that is compatible with long-term, global, sustainability principles grounded in credible, consensus-based science, economic freedom and geopolitical security



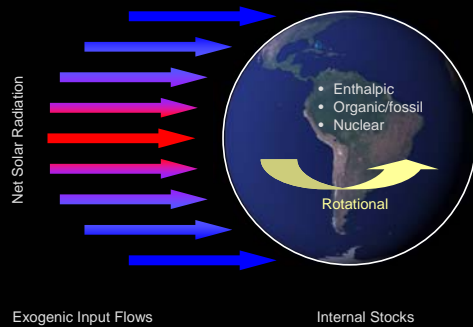
MY ASSUMPTIONS

- As scientists, we are governed by inviolate, scientific laws
- As citizens, we are influenced by our individual political convictions
 - Content
 - Intensity
- Globalization has global consequences
- Uniquely human capacities (e. g., technology, history) impose a cumulative *ecological trajectory*

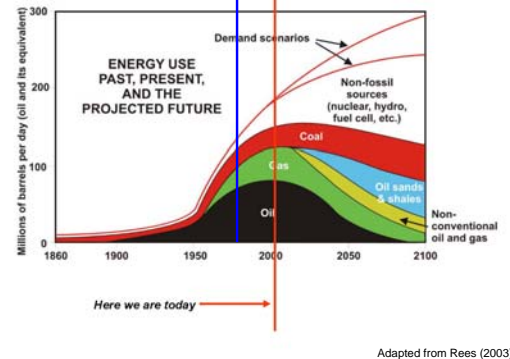
SCIENTIFIC FUNDAMENTALS

- Conservation Laws
 - Mass
 - Momentum
 - Energy
- Thermodynamic Laws
 - Energy entering a system is neither created nor destroyed
 - In real systems, energy is degraded, processes are irreversible, system entropy never decreases etc.
 - Absolute zero is a practical impossibility

SOURCES OF PRIMARY ENERGY IN THE ECOSPHERE



THE "HUBBERT PEAK" OF U. S. DOMESTIC OIL EXTRACTION



A COUPLE OF TRUISMS

- Domestic extraction of [] will cease when one barrel of it is required to extract one barrel of it from its most accessible reservoir
- Extraction of fossil fuels – among other things it accomplishes, and whatever the ecological implications might be – moves energy and carbon from the *lithosphere* to the *ecosphere*

A SUSTAINABILITY CONJECTURE

No terrestrial ecosystem of any scale can be considered sustainable if it must be subsidized indefinitely by non-renewable energy

WHY ENERGY, AND NOT MATTER?

- ✓ Both matter and energy are conserved
- ✗ There is no “mass sink” equivalent to the inevitable increase in system entropy
- ✓ We can conceivably recycle matter *ad infinitum*...
- ✗ ...given an inexhaustible source of available energy to do so
- ✗ Irreversible processes are the norm: energy is conserved, but *its ability to do work* is not!

EXAMPLE #1

- Recommendation: *Build an advanced weapon to bring the war to a rapid close and save American lives*
- Application: *²³⁵U enrichment at K-25/Y-12 in Oak Ridge, TN, 1942-1945*
- Marginal Energy Costs:
 - Mechanical energy to transport, pulverize ore; compress UF₆
 - Thermal energy to accelerate isotope diffusion
 - Electromagnetic energy to enhance isotope separation
 - Implication: “Fat Man” and “Little Boy” were highly concentrated fossil-fuel bombs

EXAMPLE #2

- Recommendation: *Increase N&P use efficiency by increasing feed digestibility/ nutrient availability*
- Application: *Steam-flake grain*
- Marginal Energy Costs:
 - Thermal energy to generate steam and pressure
 - Fluid energy to pump water, transport grain
 - Mechanical energy to drive rollers

EXAMPLE #3

- Recommendation: *Reduce volatile-solids loading to lagoons to reduce odorant emissions*
- Application: *Solid-liquid separation via settling basins*
- Marginal Energy Costs:
 - Mechanical energy to mine concrete aggregates, excavate basins
 - Thermal energy to manufacture cementing agents
 - Diesel fuel energy to transport materials, harvest and land-apply sediments

EXAMPLE #4

- Recommendation: *Increase break-even distance for hauling manure profitably as a phosphorus source, and reduce weed and pathogen viability to reduce pesticide use*
- Application: *On-farm composting*
- Marginal Energy Costs:
 - Mechanical energy to handle manure, turn compost
 - Biological energy to increase pile temperature, evaporate water, oxidize organic matter to CO₂, NH₃ and trace gases
 - You get the idea by now

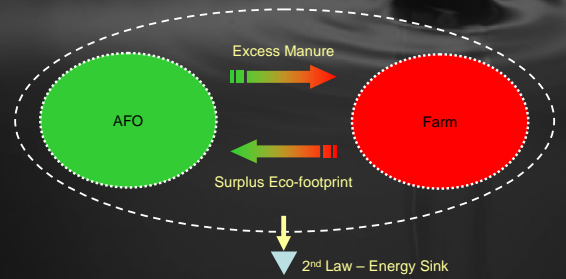
EXAMPLE #5

- Recommendation: *Take advantage of sparse populations by importing water from other places to perpetuate the feedyard industry in the Texas Panhandle*
- Application: *Coastal desalination plants and pipelines to the High Plains*
- Marginal Energy Costs:
 - Electrical energy to drive reverse osmosis systems, pump desalinated seawater, etc., etc.
 - Again, we’re trying to accelerate what the ecosphere already does for us using solar energy

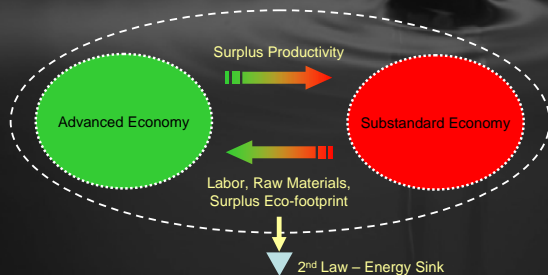
WHY NOT WATER, THEN?

- We already know how to make pure water out of impure water
- If a region or industry is water-limited, all it must do is adopt a suitable water-purification technology, and the problem is solved
- We do not have that luxury with energy
- Water, cash and nitrogen are *universally* fungible; available energy is only *locally* fungible, and trade merely obscures the fact

TRADE COUPLES ECOSYSTEMS



GLOBALIZATION COUPLES DISTANT ECOSYSTEMS



TWO DIFFERENT ACCOUNTING TECHNIQUES

“We cannot manage what we cannot measure”

ECOLOGICAL FOOTPRINT

(W. REES ET AL.)

The *per capita* area of ecologically productive land and/or ocean needed to sustain an ecosystem continuously by:

- Providing all of the material and energy resources that it requires; *and*
- Safely assimilating all of the wastes that it generates
- Does it exceed the EP area available?



ENERGY: EMBEDDED ENERGY

(H. T. ODUM ET AL.)

The available energy having an arbitrary reference quality (e. g., solar radiation) previously required – directly and indirectly – to make a product or service

- Normalizes available energy to common units (“emjoules”)
- Accounts for transformations among energy types differing in their ability to do useful work



THE PARADOX OF EFFICIENCY GAINS

- Decline of the High Plains Aquifer has accelerated despite irrigation regimes that approach or exceed 95% application efficiency (Marek, 2005; Allen, 2006)
- American farms have doubled their energy efficiency since 1978...still, due to more advanced processing, U.S. agriculture uses at least ten calories of fossil energy for every calorie of food energy produced (Miranowski, 2004; [acb] Lovins, 2005)
- My new 3GHz PC still takes 4 minutes to boot up
- We plow efficiency savings back into the enterprise to maximize profit, not reduce net inputs

A COROLLARY OR TWO

No ecosystem can be considered sustainable if its aggregated ecological footprint exceeds the ecologically productive area of the earth...

...we are part of that ecosystem!

As we approach the limits of our easy access to energy, the defining economic currency will be dominated by availability of energy units rather than by an artificial currency, be that gold or dollars.

*Paul Weisz
2004*

SACRED COWS UNDER THE GUN

- Why must our common language *necessarily* be (American) English?
- Why must our economic currency *necessarily* be the dollar, the yen or the peso?
- **More generally, what good is any *arbitrary* frame of reference as we approach the hard, geophysical limitations of our ecosphere?**
- **Is there any obvious, fundamental reason we should restrict our economic thinking to one-dimensional currency?**

MORE QUESTIONS, FEWER ANSWERS

- What is the nature of a so-called "right" to safe, healthy food and adequate nutrition? Is it...
 - ...a human right?
 - ...a Western right?
 - ...an American right?
 - ...a rich American right?
 - ...a right at all?
 - ...elitist even to ask the question?
- If we wanted to regulate inorganic fertilizer N or P on the same basis as manure-borne N or P, what would be the common currency?

Thank God for \$3.50 gasoline... We are criminally unserious about energy independence, and we will pay the price.

*Charles Krauthammer
2005*

Indeed, it has been said that democracy is the worst form of Government except all those other forms that have been tried from time to time.

*Winston Churchill
1947*

THE BLACK-GOLD STANDARD: A WORKING DEFINITION

Given a certain enterprise, a certain level of ecological stress or a certain product, assuming no energy were available from non-renewable sources, how much equivalent solar energy (or power) would have to be set aside and dedicated to sustain that enterprise, manufacture that product or mitigate that stress?

In the long run, we're all dead.

*John Maynard Keynes
1923*

SOME MODEST ACTION ITEMS

- Can we begin today learning to build energy or eco-footprint analysis into the discussion of our research results, as we have been historically urged to do concerning safety implications?