Justifications for Energy-Saving Technology

A matter of energy and environmental policy

Dr. Ross McCluney
Principal Research Scientist
Florida Solar Energy Center
A research institute of the
University of Central Florida

Energy Saving Technologies

Energy Conservation and Renewable Energy Sources

- Energy-efficient appliances, including
  - Illumination systems
  - Refrigerators, etc.
- Energy-efficient building design
  - Envelope
  - Windows
  - HVAC
- Renewable Energy Systems
  - Direct Solar – for heating and electricity
  - Wind
  - Waves, hydro, ocean currents, ocean thermal, etc.
- All require you to pay more (or less) upon installation while reaping savings over time. (Example of less: Better windows can reduce HVAC size and cost.)

Traditional Energy Accounting Begins with Costs and Savings

- First are the dollar costs of "extra" features in the building, compared with the base case.
  - Extra cost of double pane, coatings, and insulating gas fill
  - Extra cost of insulated roofs, walls, and window frames
  - Extra cost of external shading devices or vegetation
  - Extra cost of more efficient appliances and HVAC systems
- Let **C** be the total of all the extra costs you incur, in dollars
- Then you have to know the dollar value of the energy *savings* in a typical year generated by these extra costs.
- This comes from an energy computer program for both the "base-case" building and the one with the extra features.
- Let **S** be the savings, the reduced energy cost attributable to the extra features over the year, in dollars per year.

Payback Time

- The Simple Payback Time SPT is

$$SPT = C/S$$

- Since **C** is in $ and **S** is in $/yr, the units of SPT are years.
- SPT is the time it takes for
  - dollar savings = extra costs of the energy-saving measures
  - assuming no change in energy prices over the years.
- With a little effort and some complicated mathematics, you can figure out the *effective payback time* or *discounted payback time* in years, accounting for changes in the price of energy (and hence your yearly dollar savings) in the future.
- ***As energy prices increase***, your dollar savings do as well, and the ***payback time shortens***.

Return on Investment

- Return on Investment (ROI) is the annual percentage rate of dollars earned, or in this case, saved, in response to an initial expenditure (the investment)
- If **C** is the cost of the investment and **S** is the savings, both defined on slide 3, then the return on the investment is the ratio of the savings **S** each year to the initial investment **C**, expressed as a percent.

$$ROI = 100\% \, (S/C)$$

- Note: ROI is 1/PBT times 100%
- **The shorter the payback time, the greater the economic return on the investment**
- The *escalated return on investment* takes account of changing future values, but a good straight ROI, as defined above, is still a good indicator of the return on the investment.

Cash Flow Analysis

- With cash flow analysis, we assume that no money is directly invested in an energy-saving technology.
- Instead money, the principle **P**, is borrowed at an interest rate **I**, and the dollar value of the energy savings is used to pay off the loan.
- If the technology saves more than the loan payment, then the *cash flow is positive* each month (or each year).
- If the technology saves less than the loan payment, then the *cash flow is negative*.
- Alert business managers are easy to convince, if offered a technology they don't pay for (the loan pays for it) which pays them a little extra each year.
- When interest rates are low, or when energy prices are high, it is easier to have positive cash flow with such a scheme.

Life-cycle Costs

- Life-cycle cost analysis seeks to consider all the costs and benefits of an energy-saving technology over the lifetime of the equipment involved.
- An investment is made.
- There are annual maintenance and service costs to add in.
- There are annual savings which may be subtracted from the costs.
- The costs and savings are projected over the system's lifetime.
- The net, end-of-life, or *life-cycle cost* is totaled and compared with the life-cycle costs of alternative investments.
- The *least* life-cycle cost technology is generally the one to use.
- This approach is well-tailored to adding in a variety of societal and environmental costs associated with the investment, *if dollar values can be placed on them*.

Net Energy Analysis

- Starts by estimating the total non-renewable energy costs to manufacture and install an energy-saving technology.
- It estimates the amount of non-renewable energy saved over the lifetime of that technology.
- If the energy savings exceed the energy costs to manufacture, i.e. if the net energy savings are positive then the investment is a good one.
- The investment is good if less nonrenewable energy is spent than the technology saves in its lifetime.
- Some renewable energy technologies are net energy losers by this measure

External Costs

- External costs are the environmental and human health costs of a business operation *that are not included in the business's profit and loss statement*.
- External costs are "off the books" and not considered a normal cost of doing business.
- People and the environment pay external costs—in tax dollars to clean up messes and in health care dollars and diminished health.

- External costs are *not included in the price of a product*. This sends misleading price signals to purchasers and perverts a free-market economy.
- *Internalizing costs* is the process of pulling external costs back into the corporations generating them, forcing them to include them in their prices offered to customers.

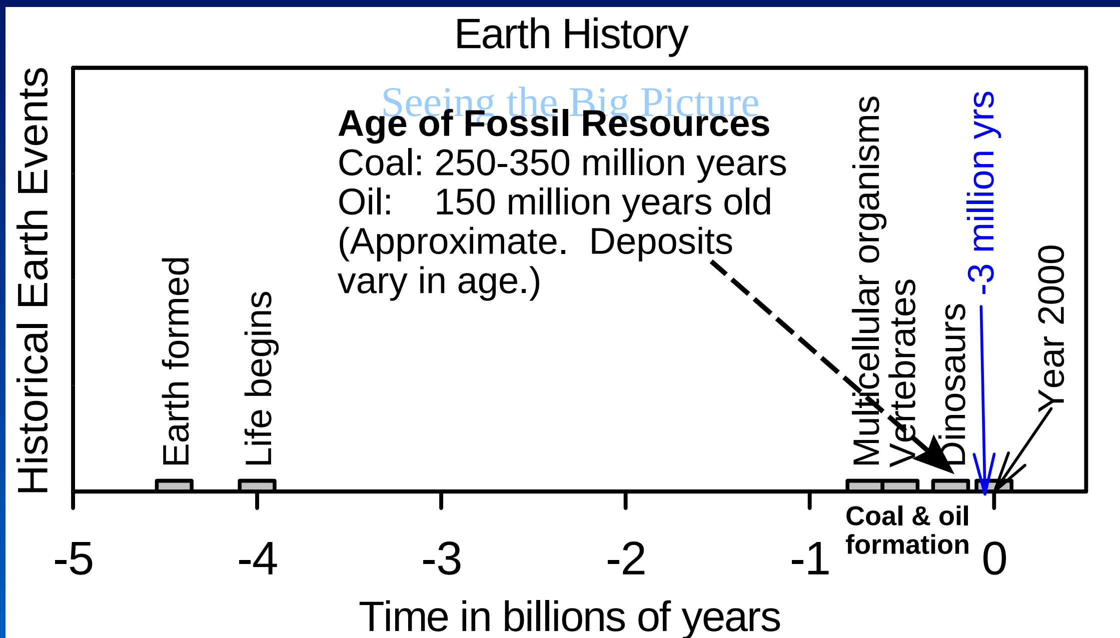
Least-cost is a powerful driver

Seeing the Big Picture

- Choosing the least cost energy option is too prevalent: And can be environmentally disastrous.
- One reason is relatively low energy prices.
- Energy codes work, but only minimally, because they aren't strict enough.
- Markets often fail to see the bigger picture, until rather late in the game, especially if they are biased in the wrong direction by government policy (such as subsidizing fossil energy).
- Let's take a larger view ....

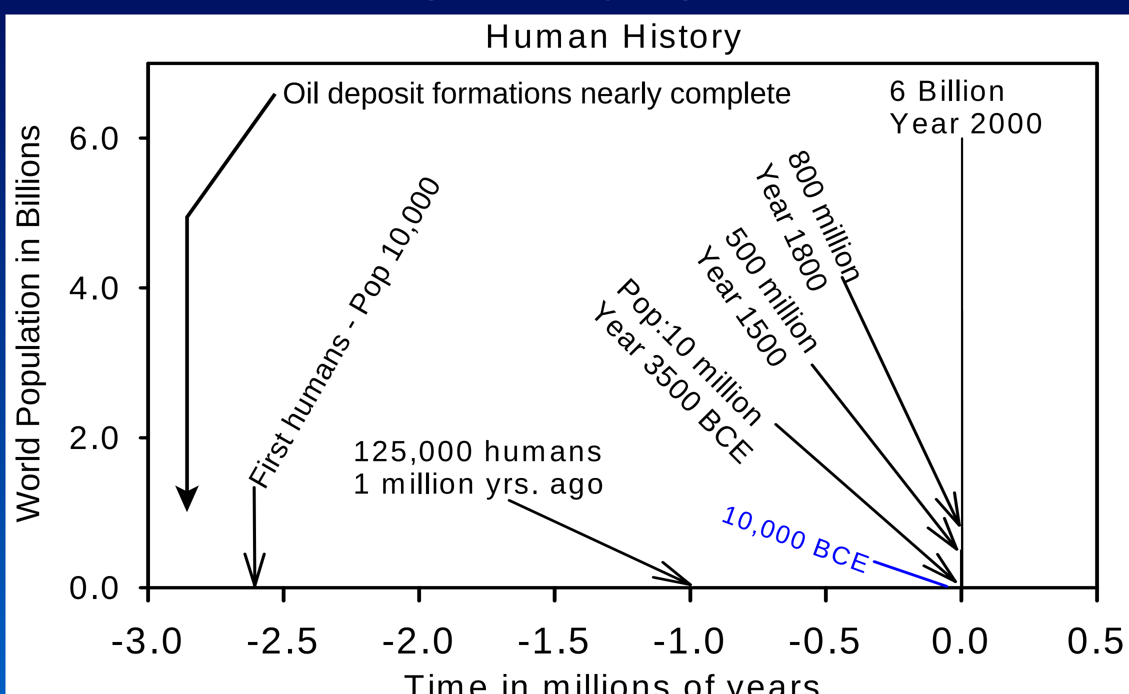
Earth History

Seeing the Really Big Picture

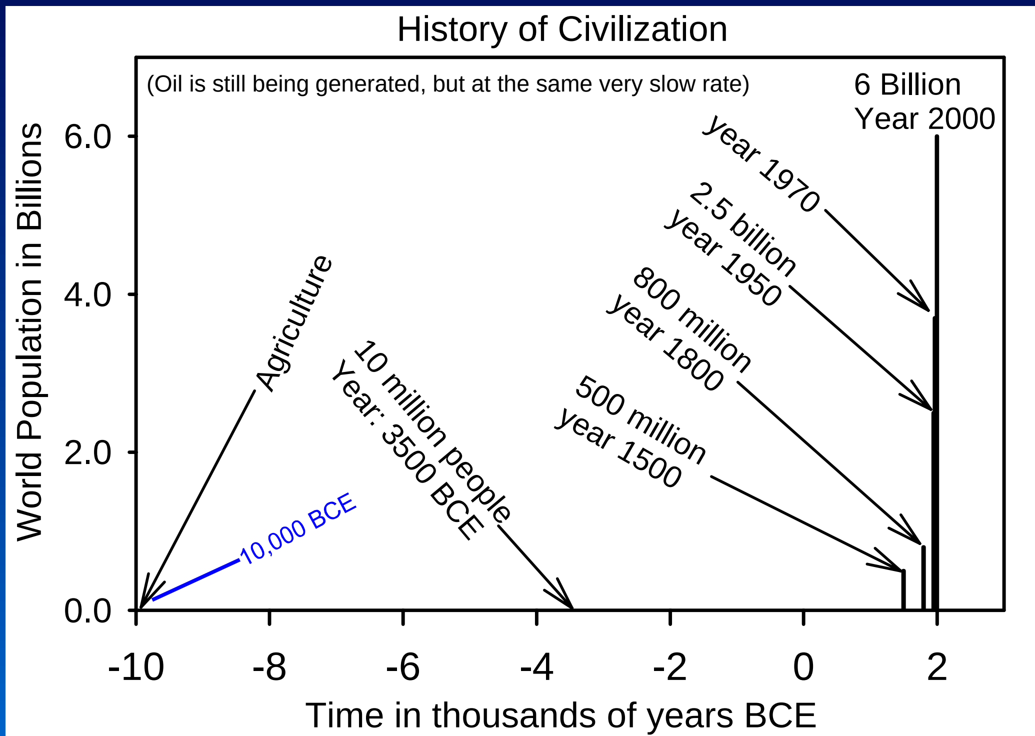


Human History

Seeing the Really Big Picture



History of Civilization



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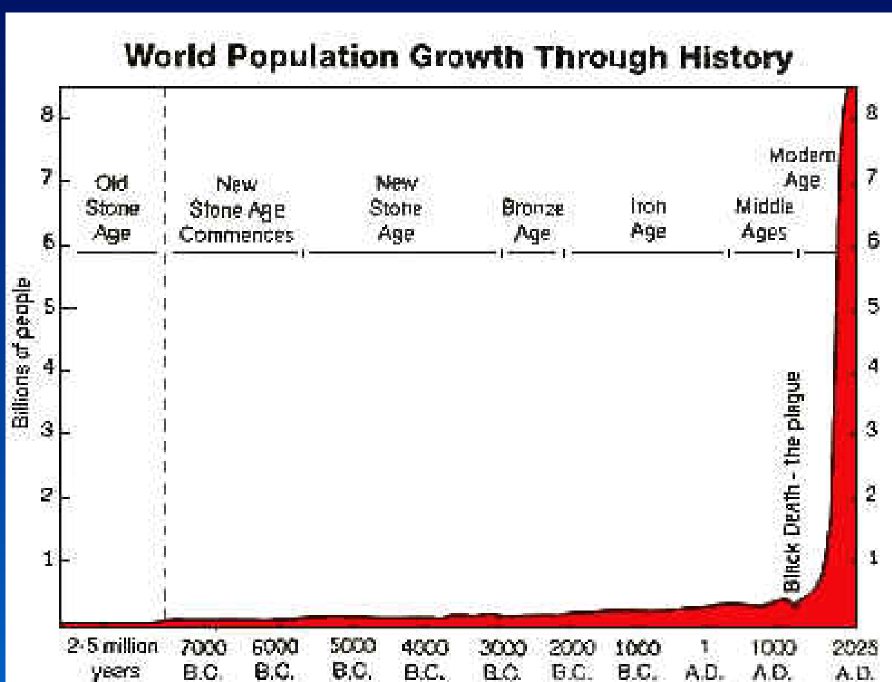
Exponential Growth



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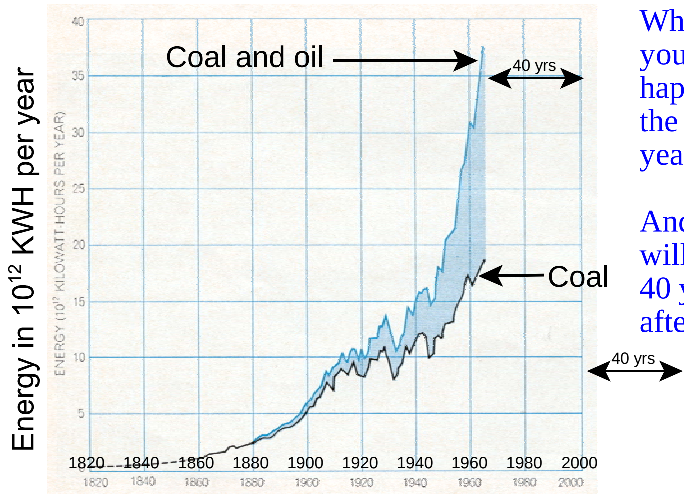
Exponential growth of world oil and coal production



ENERGY CONTRIBUTION of coal (*black*) and coal plus oil (*color*) is portrayed in terms of their heat of combustion. Before 1900 the energy contribution from oil was barely significant. Since then the contribution from oil (*shaded area*) has risen much more rapidly than that from coal. By 1968 oil represented about 60 percent of the total. If the energy from natural gas were included, petroleum would account for about 70 percent of the total.

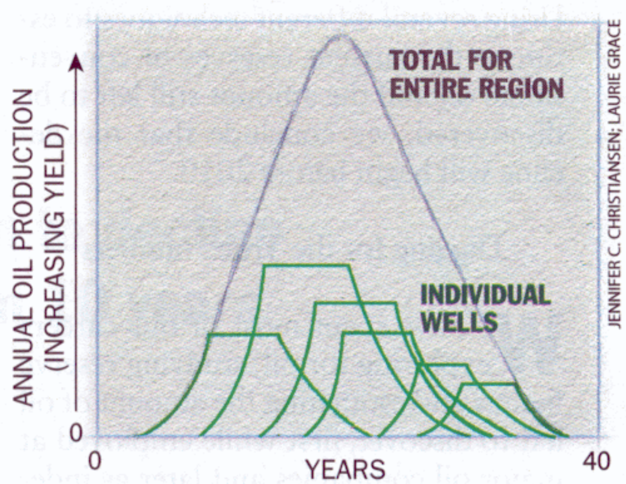
What do you think happened in the next 40 years?

And what will happen 40 years after that?

M. King Hubbert, "The Energy Resources of the Earth," *Scientific American*, September 1971, pp. 60-70.

The Future of Oil Production

FLOW OF OIL starts to fall from any large region when about half the crude is gone. Adding the output of fields of various sizes and ages (*green curves at right*) usually yields a bell-shaped production curve for the region as a whole. M. King Hubbert a geologist with Shell Oil, exploited this fact in 1956 to predict correctly that oil from the lower 48 American states would peak around 1969.



C. J. Campbell and J. H. Laherrere, "The End of Cheap Oil," *Scientific American*, March 1998, pp. 78-83.

The Peaking of U.S. Oil Production

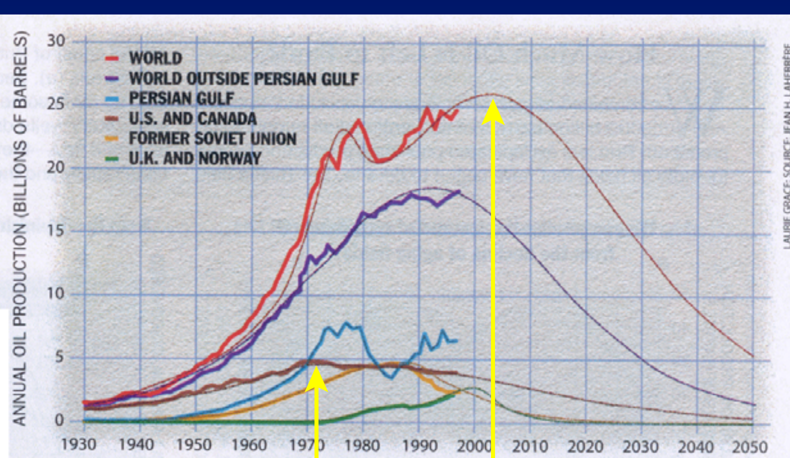
A massive failure of policy

- The U. S. peaked its production of oil in 1972.
- Thereafter we turned to other countries to make up the shortfall.
- We had a very unique opportunity in 1972 to initiate a crash program to convert to energy conservation and renewable energy sources.
- We missed that opportunity.
- And now we import more oil than any other nation on earth.
- When will ***world*** oil production reach its peak?

The Peaking and Decline of World Oil

GLOBAL PRODUCTION OF OIL, both conventional and unconventional (*red*), recovered after falling in 1973 and 1979. But a more permanent decline is less than 10 years away, according to the authors' model, based in part on multiple Hubbert curves (*lighter lines*). U.S. and Canadian oil (*brown*) topped out in 1972; production in the former Soviet Union (*yellow*) has fallen 45 percent since 1987. A crest in the oil produced outside the Persian Gulf region (*purple*) now appears imminent.

U. S. production peaked in 1972, only 3 years after 1969, the year Hubbert predicted (in 1956) it would happen.

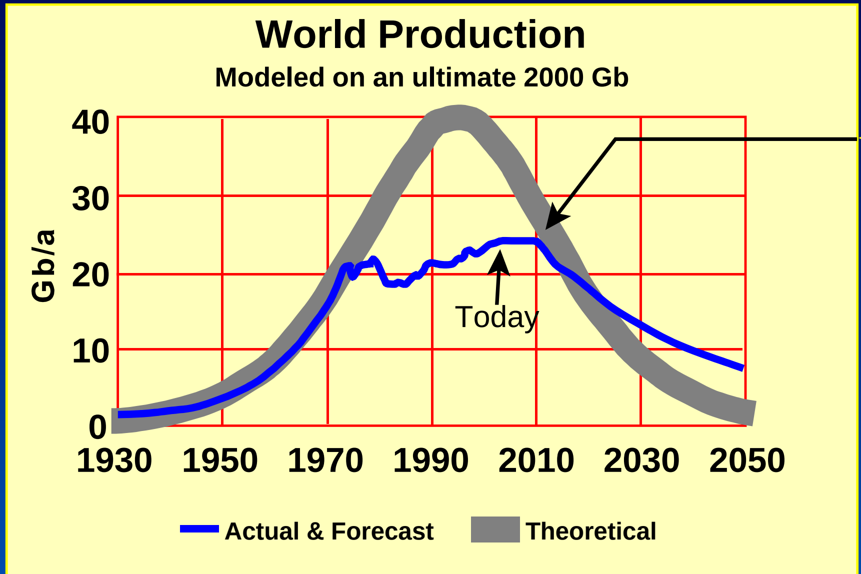


C. J. Campbell and J. H. Laherrere, "The End of Cheap Oil," *Scientific American*, March 1998, pp. 78-83.

U. S. peak 1972

World peak

World Oil Depletion Estimate



Source: C. J. Campbell, “The Oil Peak, a Turning Point,” Solar Today, July/August 2001, p. 41.

Current estimates of the date of peak world oil production:
“**2010**,” made by Campbell and Laherrere in 1998, op.cit., p. 82.
“**Before 2004**.”, made by Deffeyes in 2001, *Hubbert’s Peak*, p. 12.
“**We may have already passed it.**” made by Campbell in 2002, private communication.

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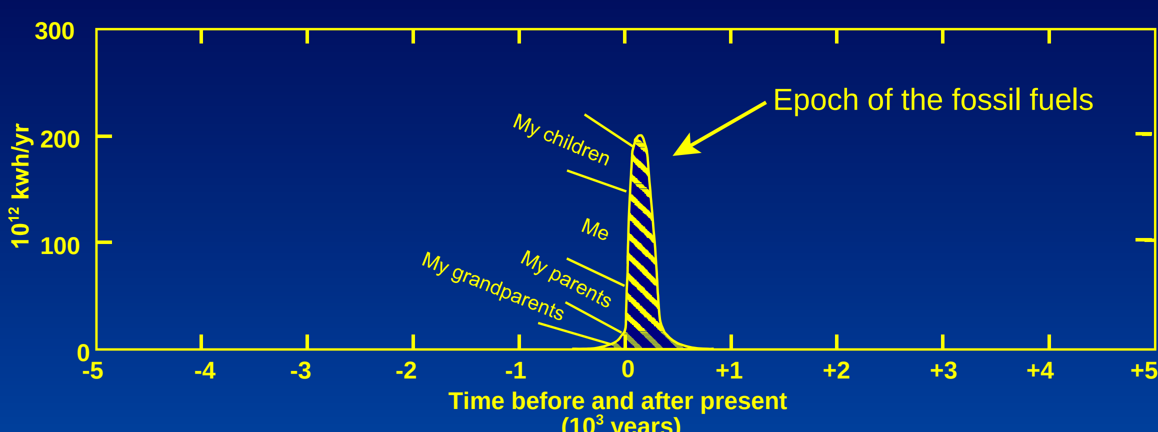
Like the flame of a candle in the long dark night



“The brevity of this in human history can best be appreciated if we plot [the above graph].” “The epoch of the fossil fuels ... is responsible for the development of our modern industrial civilization....”

M. King Hubbert, “The World’s Evolving Energy System,” Am. J. Phys., Vol. 49, No. 11, Nov. 1981, p. 1026.

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What Does All This Mean?

How does it relate to justifications for energy-saving technologies?

The following are my views.

To some extent they reflect the interests of the U.S. Department of Energy in reducing fossil energy use.

For example, DOE's zero energy home program. And the President's pronouncement that global warming is real and of human origin.

What follows are the views of neither the Florida Solar Energy Center nor the University of Central Florida

Conjectures on Possible Future Consequences of Declining World Oil Production

- Transportation fuel prices will increase
- Prices for transported commodities will increase
- Electricity and fuel oil prices will increase, along with the prices of the foods most heavily dependent upon fossil fuel
- A rush to conserve petroleum for more durable uses
- A push to relocate places of work closer to homes and vice versa
- Pressure on the "have-not" nations to develop on a much lower energy model than the current industrialized world one
- Pressure on the industrialized nations to use less, leaving more for developing nations to consume as they develop
- How long until this starts happening?
  - — Middle of this decade
- How long do good energy efficiency measures last?
  - — Several decades
- So how much energy conservation and renewable technology did you say you wanted for your building?

The World Economy's Response

Many people have proposed various scenarios

- Amory Lovins suggests that radical resource efficiency will dominate the market for energy-consuming systems.
  - It will happen faster than the decline in world oil production.
  - There will be no crisis as we run out of oil.
  - Energy efficiency and substitute fuels will rule the day.
- Suggested substitutes include
  - liquid fuel from renewable biomass such as corn
  - hydrogen derived from solar-powered electrolysis of water
  - other renewable sources.
- It is true that world population growth will continue. The per capita use of energy will go on growing, especially in China, India, and other parts of the world. But radically increased energy efficiency will save the day. Along with increased use of renewable energy sources.
- Both of these will occur on a massive scale. Some say it will be enough to keep ahead of growing demand.

But there may be some limitations

- Some renewable energy systems may not pan out, due to
  - Technological problems
  - Cost problems
  - Limited resource availability
  - Adverse environmental consequences
- Public policy currently fails to offer strong incentives for energy efficiency or renewable sources. This may not change fast enough.
- As China, India, Africa, and South America grow and demand more energy-consuming technologies, new energy demand can outstrip improved energy efficiency and more use of renewables.
- What about the base of existing, already installed energy-consuming systems? They can't become efficient overnight.

"Who will fuel China?"

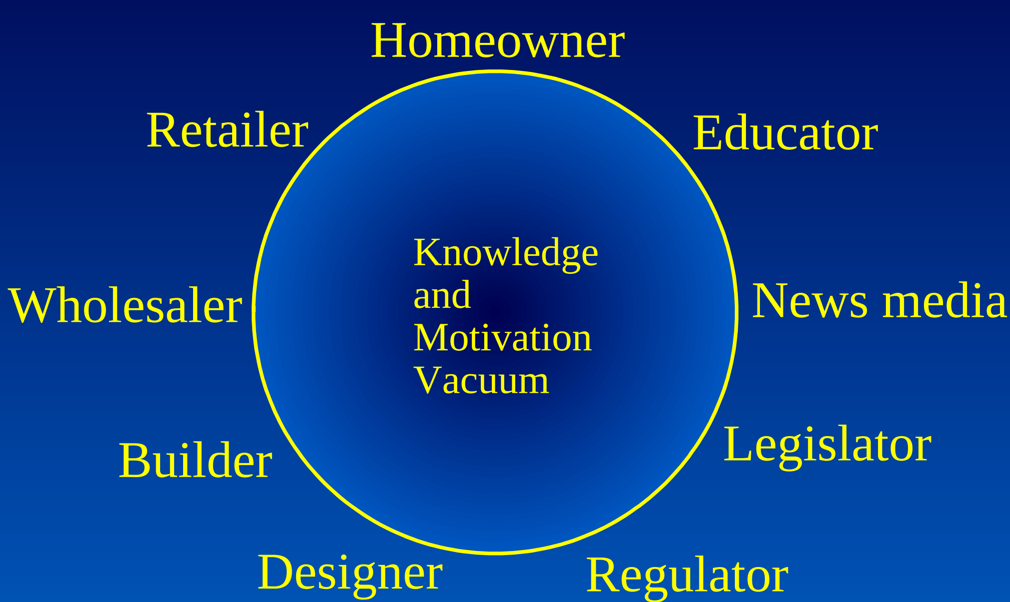
Thomas E. Drennen, John D. Erickson, *Science*, Vol. 279, 6 March 1998

- Throughout [the 1990s] China's real gross domestic product (GDP) has grown an average of over 11% each year.
- To help fuel her unprecedented growth, in 1993 China became a net importer of oil for the first time in history.
- The impact of China's total fossil fuel consumption also dominates the politics of global environmental change.
- Chinese oil imports could reach 7 to 8 million barrels per day by 2015 and 13 to 15 by 2025.
- Together with projected global declines in oil production in 20 years, these demands on the global oil market pose a serious threat to future global energy security.

In light of this

- Shouldn't we buy the *most* energy-efficient technology and install the best renewable resource available?
- The reality: In the face of the coming oil shortages, we continue to purchase what is cost-effective **only in a narrow monetary sense**. When energy prices are low, *more* energy consumption results, not less.
- So vendors have trouble stocking and selling better products.
- There is an inherent conflict between what the "free market" wants and what DOE and the concerned public want. And there is the natural human reluctance to change, a failure to anticipate future pressures and respond ahead of time.
- Market consequences →

The Circular Chain of Failure



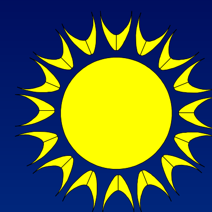
"A chicken and egg problem in a dog eat dog world."

Perhaps we need a market restructuring, toward more efficient products.

Market Restructuring

- How can we encourage energy efficiency in new buildings?
  - **A market-based approach** Utilizes education, technical information, design assistance, financial incentives — to accelerate *voluntary* adoption of energy efficient building practices.
  - **The regulatory approach**. Energy codes are arguably the most cost-effective and permanent mechanism.
- Energy codes — the purest form of market transformation:
  - **They affect all buildings**
  - **They give clear signals to manufacturers and distributors**
  - **They are persistent**
- Only ***you*** can influence energy code revisions
- It is a political act

FSEC information resources



- Information and educational tools
  - Publications
  - Web site
  - Short courses
  - Technical assistance
- Contribute to market transformations through:
  - Education
  - Technical information
  - Design assistance
- Purpose: accelerate voluntary adoption of energy efficient building practices
- We do not set public policy.
- That's the public's job — and its political leaders.

Public Policy

Failures of understanding, of education, of leadership, of investigative journalism, and of individual responsibility can keep us from moving to radical resource efficiency

- **What you seldom hear in the media or from politicians:**
- **Energy should cost more**, better reflecting its true cost
- Government should stop subsidizing fossil fuels, keeping energy prices arbitrarily low and sending wrong price signals
- If prices were **higher**,
  - First cost would be less important
  - Life-cycle costing would be more widely used
  - Transportation energy use would decrease
  - Petroleum would be saved and conserved as the precious commodity that it is
  - Extreme energy efficiency would be universal
  - Renewable energy would be pushed to the environmental limits
- And both the demand for and the supply of radical energy efficiency and renewable energy technology would be much greater!

Security,

Post 9/11

what is real security?

Amory B. Lovins and L. Hunter Lovins

YES! Journal Spring 2002

Lee Celano

America's security faces many serious threats. Strategic planners, however, have tended to focus almost exclusively on the *military* threat. They have

...ining the capability to black out whole cities, and cause physical damage to equipment.

Reliance on fossil fuels and their extended pipelines contributes to our insecurity. Even where fuel is extracted from politically stable regions, it must be safely transported via accident-prone ships, trucks, rail, or pipeline. On October 4, 2001, a drunk shot a bullet through the Trans-Alaska Pipeline, shutting it down for 60 hours and spilling 285,000 gallons of oil. Previously, the pipeline has been shot at on over 50 occasions. A disgruntled engineer's plot to blow up critical points then profit from oil futures trading was thwarted by luck two years ago.

How, then, can America become less vulnerable to attack and more resilient to mishaps that do occur? How can we prepare for a future that may hold increasing uncertainty, unrest, and even violence? The answer may be found by basing engineering on nature. Natural systems are efficient, diverse, dispersed, and renewable, hence, inherently resilient.

The most resilience per dollar invested comes from using energy very efficiently. Minimizing energy waste

"Strategic planners...have tended to focus almost exclusively on the *military* threat. They have largely ignored equally grave vulnerabilities in vital life-support systems such as our energy, water, food, data processing, and telecommunications networks." To be more resilient to mishaps, Americans must decentralize. "The most reslience per dollar invested comes from using energy very efficiently."

Real Security - 2

Amory and Hunter Lovins:

- "We're looking for security in all the wrong places."
- "Did we put our young people in 0.6 mile per gallon army tanks because we did not put them in 32 mile per gallon cars?"
- "Real security begins at home and is built on communities that are self-sufficient and sustainable."

Conclusions - 1

Substantial increases in efficiency of fossil energy use are essential

- Designing buildings ***down*** to a minimal energy code
  - represents failed opportunities for slowing the growth of energy demand
  - ignores comfort, produces more pollution, contributes to global warming
  - in some cases is not cost-effective even in the traditional economic sense
- Designing ***up*** to greater energy efficiency is a patriotic act—a commitment to the future of humanity and of the Earth.
  - It leads to higher quality homes, that are more comfortable and have lower energy bills.
  - It reduces pollution, lessens global warming, reduces dependence on foreign oil.
  - It directly contributes to a sustainable future.
- Better homes attract more customers, permit higher prices, lead to greater profits for sellers, and save energy for homeowners.
- Designing ***up*** not only helps us enjoy our new homes but makes us feel good about ourselves and our future.

Conclusions - 2

- The last thing we want is to design down to the least common denominator, just barely meeting energy codes
- Achieving only the minimum necessary energy performance represents failures in
  - **Understanding**
  - **Responsibility**
  - **Policy**
  - **Leadership**
- Our goals should be
  - **Disconnect from the electric utility grid to the greatest extent possible.**
  - **Install high performance windows and HVAC systems, and very well insulated walls, ceilings, and floors**
  - **A building in Florida and elsewhere can drastically reduce its energy requirements and be more comfortable and enoyable as well.**
  - **If you are not yet ready to disconnect, at least strive for maximum fossil energy use efficiency.**

Getting the Products & Systems

- Pressure building designers, wholesalers, manufacturers, and builders to specify, manufacture, sell, and install high-performance components, subsystems, and systems
- Since we may already have passed the peak in world oil production . . . .
- And if you value security, freedom, motherhood, and apple pie . . . .
- Work to lessen U.S. dependence on foreign oil through more energy efficient building designs.
- Work to exceed Energy Star requirements and implement more stringent energy codes, by wide margins.

The Really Really Big Picture – 1

- Earth is primary. Humanity is derivative.
- Earth is self-propagating, in the sense that life forms come forth and multiply, but not beyond what is sustainable.
- Those which work in the system continue.
- Any species that doesn't fit, doesn't work within the overall system gets kicked out and doesn't continue.
- Humanity has broken away from its former constraints, temporarily, and has overwhelmed all other life communities.
- The Earth is left with a species that is out of control, overwhelming all others.

The Really Really Big Picture – 2

- Most of the recommendations I have given to this point are little more than incremental, patchwork, ineffective, do-goodisms — when they fail to also deal with a species out of control.
- This is why making permanent and truly sustainable reform is so difficult and why so many of our efforts in this regard are failing us.
- For true and lasting reform to be possible, for our struggle toward sustainability to be less of a struggle against powerful opposing forces, we need a major conceptual shift — a new worldview.
- Once we have this, it all will become so much easier.
- If you want more information about this, see me.

Any Questions?

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Additional Information & Resources

- For more information visit our windows web site:

www.fsec.ucf.edu/~fen

- This presentation is at

www.fsec.ucf.edu/download/fenestration/ESmartPolicy

- Energy Crisis:

www.dieoff.org

- The Really Really Big Picture:

www.futureofhumanity.org

- Please fill out your evaluation questionnaires

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