Energy Policy Models and Technology Characterization: *Decided Room for Improvement. . .*

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A Thesis and Some Opening Caveats

- The central station paradigm and alleged "Carnot efficiencies" (among other ideas) have tended to erode our best thinking about all of our available energy efficiency options – to the detriment of real economic productivity, improved environmental quality, and the equitable distribution of wealth.
- A close examination suggests any "practical limits" to efficiency improvements are largely non-existent in the foreseeable future.
- However, this not to say there are no economic barriers or environmental problems to be resolved as we seek an appropriate level and mix of energy efficiency technologies and policies.
- All examples used in this presentation are intended only to highlight future opportunities rather than to underscore precise efficiency options or policies.
- And while I reinforce this point in my last slide, the numbers, comments, and analyses do not necessarily reflect the opinion of either the Environmental Protection Agency or the US Government. All errors (in fact or judgment) remain my own.
- ***Mostly, I hope to encourage further inquiry as we seek improved policy analyses rather than to argue for a specific outcome.***

A Short Historical Perspective

The year 1970 is not an especially important one in the history of the United States

- In 1970 the movies "Love Story" and "M*A*S*H" drew crowds to air-conditioned theaters. The Chicago Seven were acquitted and Janis Joplin died. And, in 1970, 18-year old James Nasworthy actually did reinvent the wheel and it popularized skateboarding.
- But, in 1970 there were no personal computers or cellular phones. Slide rules were still used for engineering calculations rather than hand-held calculators. In 1970 fax machines did not exist other than for highly specialized uses such as weather mapping.
- There were no catalytic converters on automobiles, no CD or DVD players in our homes. Technologies such as electronic ballasts, low-emissivity windows or industrial "high-lift" heat pumps had yet to be invented. And carbon nanotubes had yet to be discovered.
- FedEx was still several years away, and the Internet consisted of just four university sites that had been connected only the previous fall.

The year 1970 is not an especially important one in the history of the United States

- In 1970, the world had yet to hear of names like Chernobyl, Three-Mile Island and the Exxon Valdez. Perhaps more important, global climate change and ozone depletion were unthinkable prospects.
- And, oh yes, 1970 was also the year when the U.S. Environmental Protection Agency was created (and it was about the time when I began my own career — although it was not with the EPA).
- ***The roughly 30-year period since 1970 is about the same period of time that most analysts and scientists now believe that we have remaining to begin dealing effectively with emerging energy constraints and global climate change. This, admittedly, is a daunting prospect.***

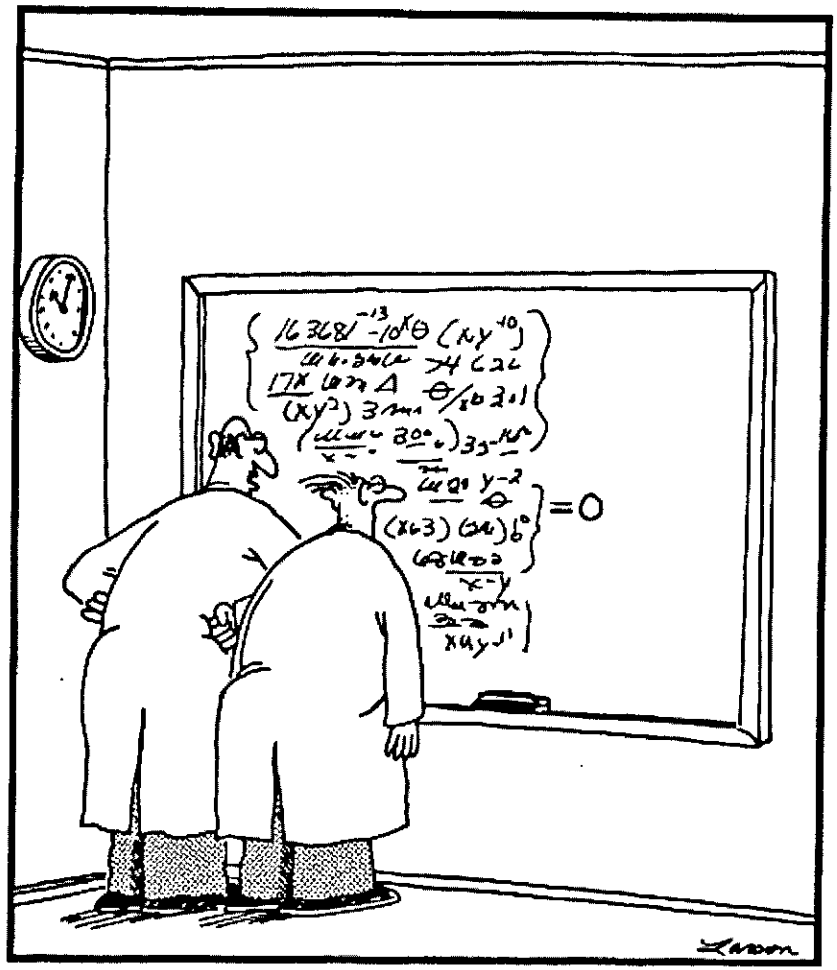
Reviewing the Long-Term Perspective

❖ Energy analysts of all perspectives suggest the likelihood of a significant increase in the cost or a shortfall in the availability of conventional fossil fuel resources by 2020 — and perhaps sooner.

❖ Economist Kenneth Boulding once commented : ***"Images of the future are critical to choice-oriented behavior."***

❖ Whether we include in our analysis nuclear, hydrogen, renewable, or non-conventional fossil fuel resources, can we afford to rule out energy efficiency?

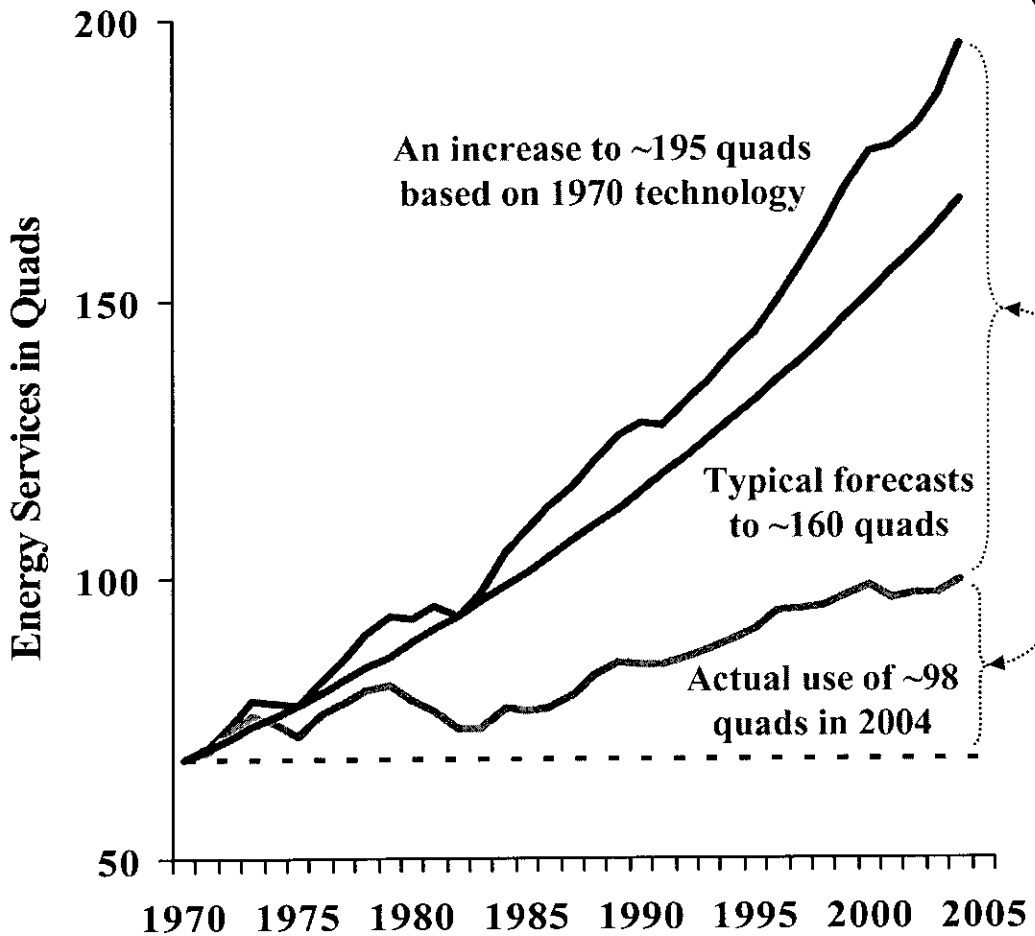
❖ ***And yet, economic models and conventional policy analyses tend to assume that energy efficiency can make only a limited — and "not always cost-effective" — contribution to our nation's energy future.***



"No doubt about it, Ellington—we've mathematically expressed the purpose of the universe. God, how I love the thrill of scientific discovery!"

Although less than infinity, the evidence clearly suggests that the role of technological change and energy efficiency is significantly greater than zero.

Without New Efficiency Technology,** Energy Use Would Be Almost 3 Times 1970 Levels



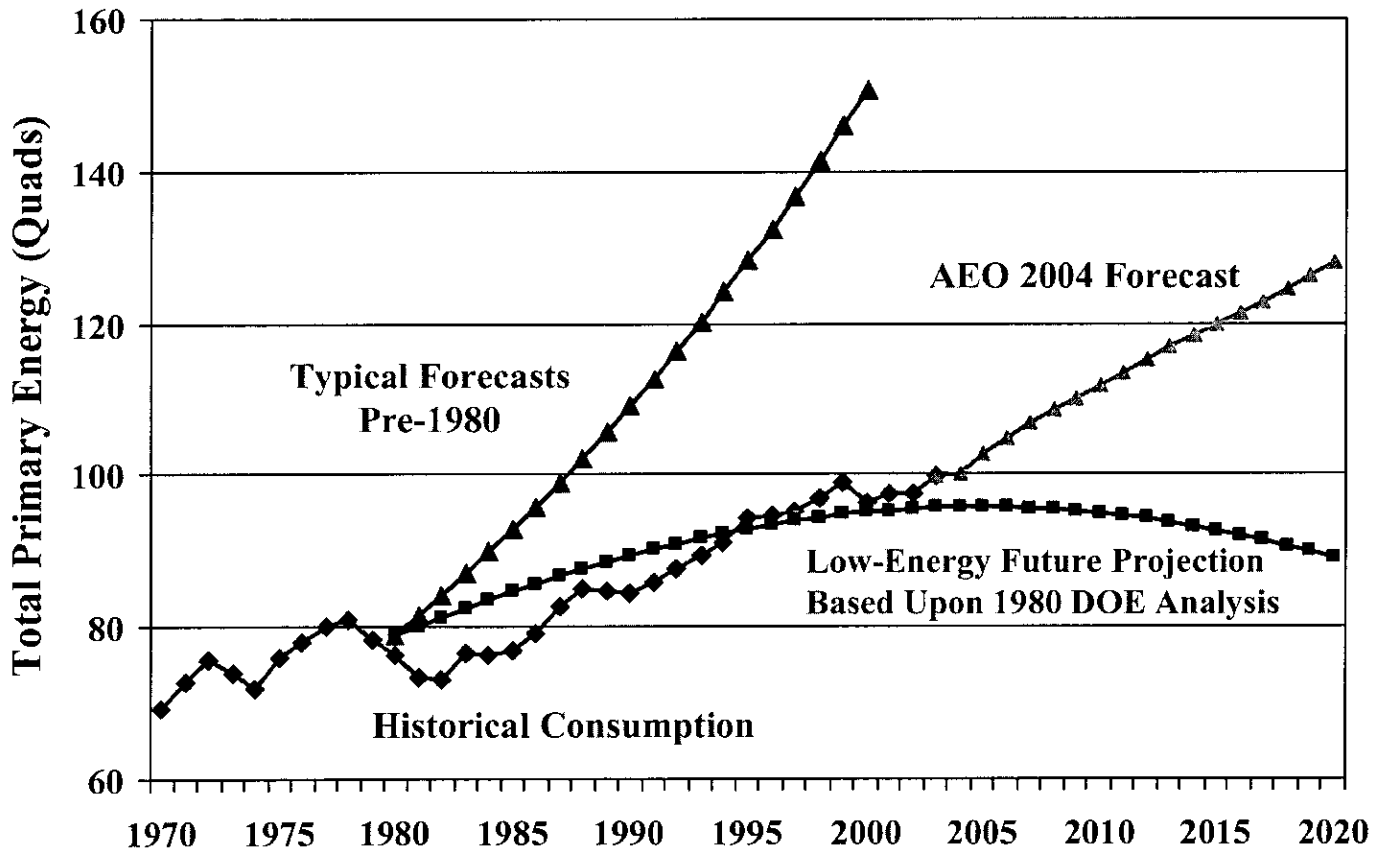
Contrast 3 Energy Patterns

- ✓ Using 1970 Technology
- ✓ Standard 1970s Forecast
- ✓ Actual energy use since 1970

Since 1970, energy efficiency has met 75% of new energy service demands in the U.S, while new energy supplies have perhaps contributed only 25% of new energy service demands.

** Where "energy efficiency" is broadly defined as the difference between the 1970 and 2004 energy intensities.

Comparison of U.S. Energy Projections: A Difference in Technology Assumptions

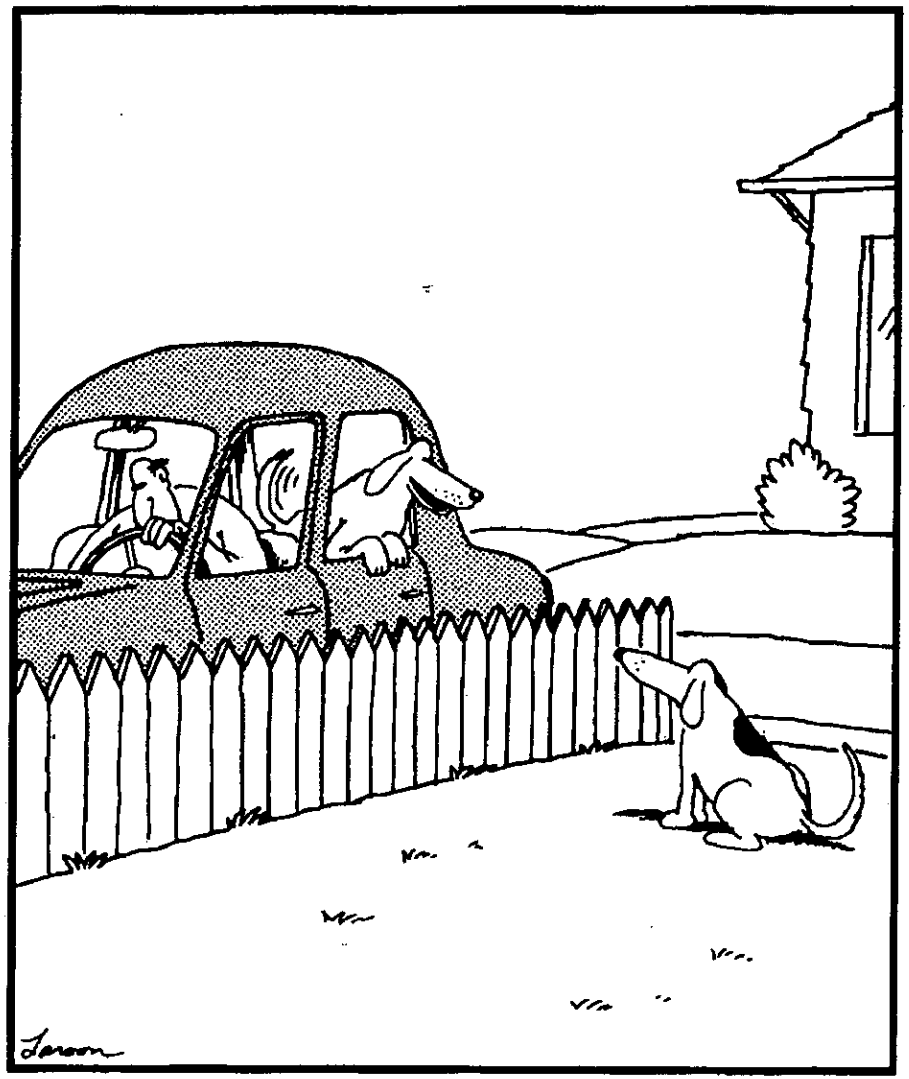


Source: AEO 2004, EPA estimates 2004, and 1980 DOE Policy Analysis

An Unfortunate Digression in the Dialogue

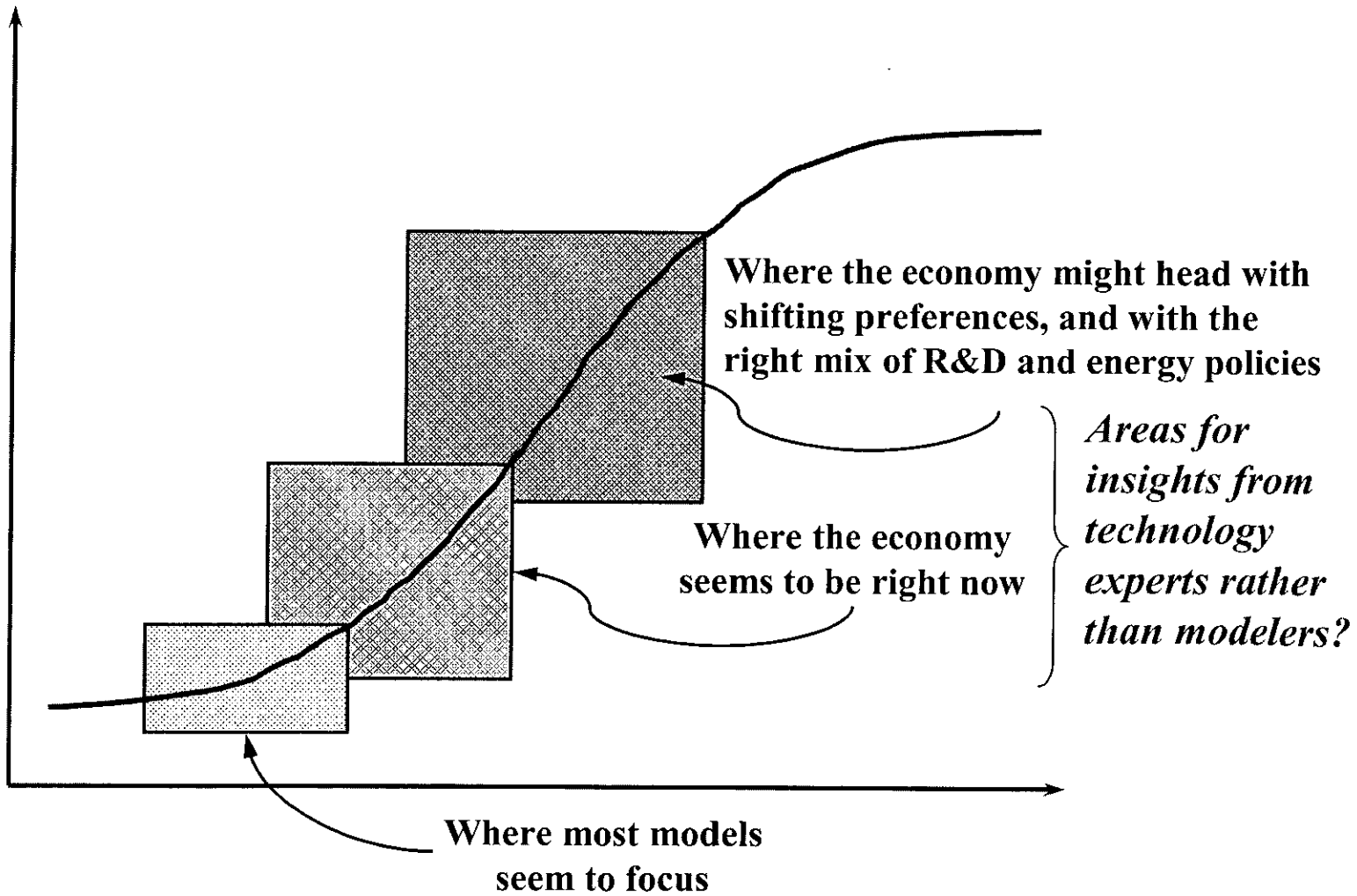
- Drawing on what they refer to as thermodynamic limits, however, Lightfoot and Green (2003), argue:
  - Maximum improvements in fuel economy will be limited to no more than 110 mpg, combined heat and power will have a minimum role at no more than 50 percent total efficiency, and other sectoral improvements will be no more than 2-3 times over current efficiency levels;
  - Assuming a world economy that expands 2.3 percent annually, and with a maximum practical limit of a ~1.0 percent annual decline in energy intensity; then they suggest that
  - A world economy 9.7 times larger in 2100 compared to the year 2000 will require 3.6 times more energy — with a very clear need for big technology.
- However, as Laitner (2004) shows, a full appreciation of chemistry, physics, and materials science (rather than combustion efficiency) indicates energy intensity reductions of 2.0 percent annually are possible — especially when future technology systems include:
  - Not only efficiency gains but also changing social preferences and policy choices affecting the type and level of service demands such transportation modes, distances traveled, use patterns, and distances traveled; and
  - The development of new materials, electronics, and productions systems.
- ***A close examination of real thermodynamic limits (rather than mere combustion efficiency), and changing patterns of energy service demands, suggest that Energy Efficiency can take us just about as far as we choose to go over the next 100 years.***

I think we can all agree that a small difference in assumptions can have a very big impact in the eventual outcome.



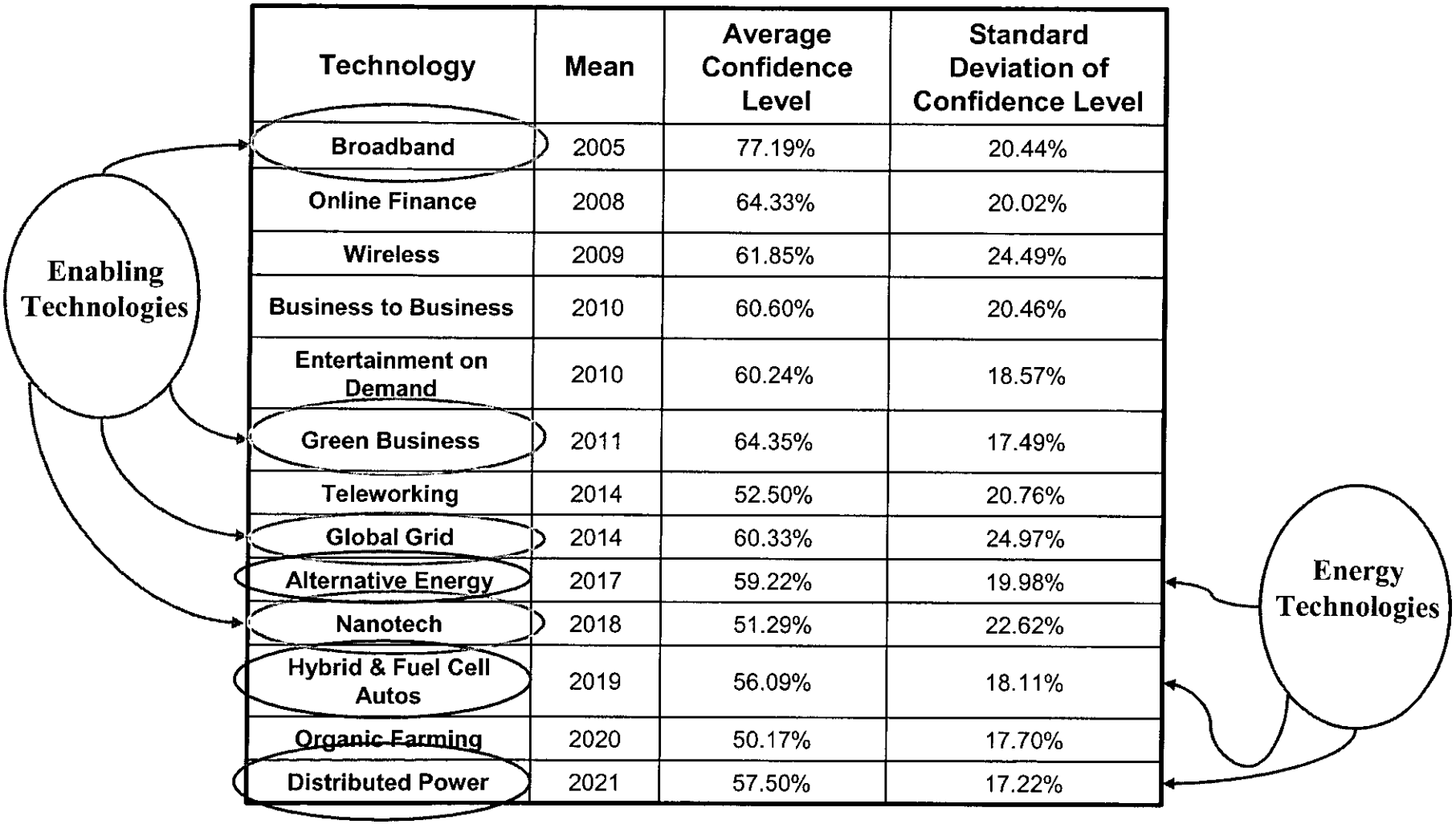
"Ha ha ha, Biff. Guess what? After we go to the drugstore and the post office, I'm going to the vet's to get tutored."

Standard Forecasts and the Technology Gains from Efficiency and Structural Improvements



The Immediate Future Does Show Some Promising Options

TechCast: Technology Market Shares at 30% By. . .



Technology	Mean	Average Confidence Level	Standard Deviation of Confidence Level
Broadband	2005	77.19%	20.44%
Online Finance	2008	64.33%	20.02%
Wireless	2009	61.85%	24.49%
Business to Business	2010	60.60%	20.46%
Entertainment on Demand	2010	60.24%	18.57%
Green Business	2011	64.35%	17.49%
Teleworking	2014	52.50%	20.76%
Global Grid	2014	60.33%	24.97%
Alternative Energy	2017	59.22%	19.98%
Nanotech	2018	51.29%	22.62%
Hybrid & Fuel Cell Autos	2019	56.09%	18.11%
Organic Farming	2020	50.17%	17.70%
Distributed Power	2021	57.50%	17.22%

Source: Results based on Technology Experts Panel convened as part of a Delphi Survey completed by TechCast LLC for the EPA Office of Atmospheric Programs, March 2004.

Standard Energy Projections versus the Recent EPA-TechCast Delphi Survey

AEO 2004 Outlook

- Hybrid and Fuel Cell Vehicles — 6% by 2025
- Non-Fossil Energy Resources — 23% by 2025
- Distributed Generation — 16% by 2025

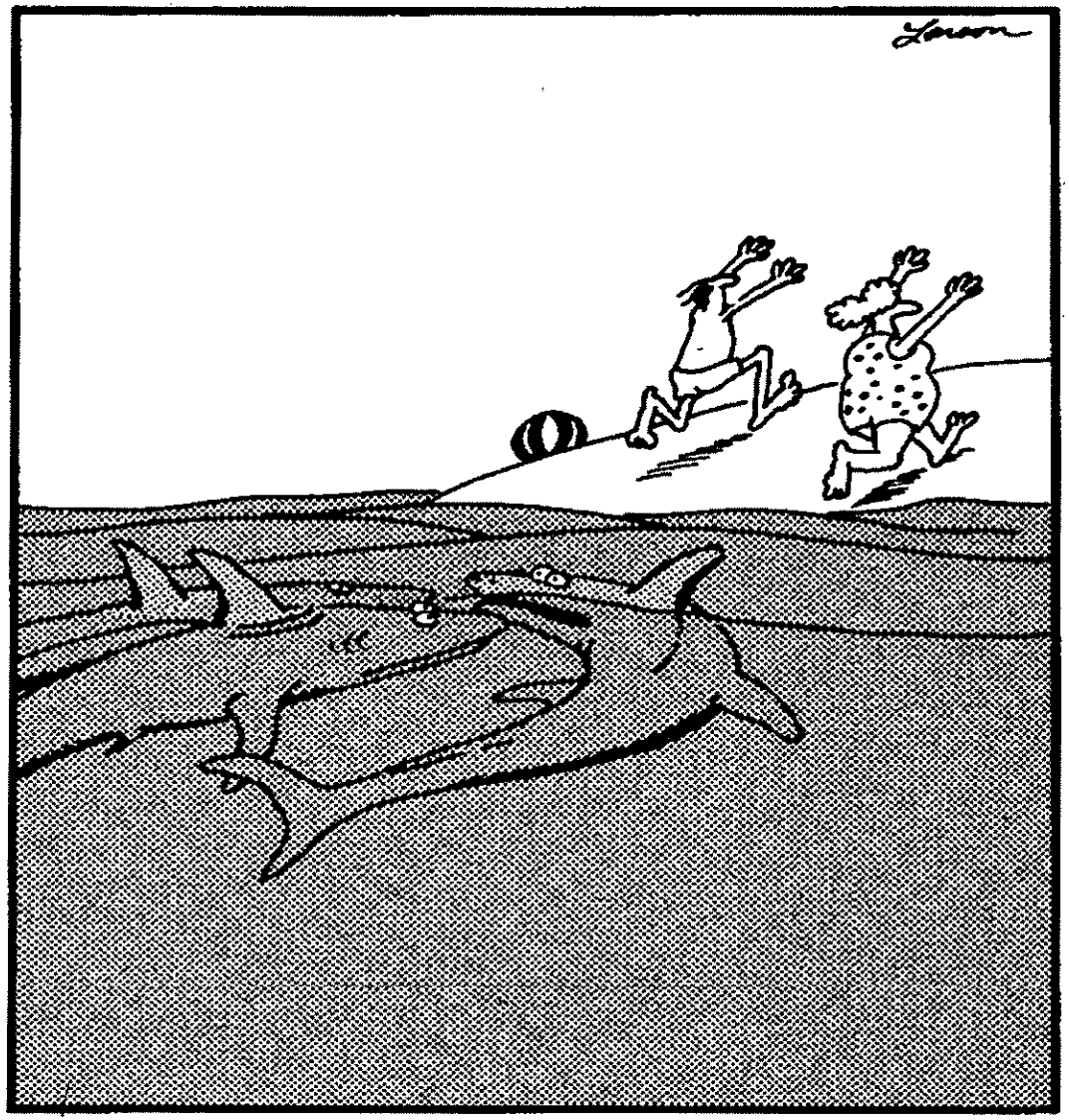
EPA-TechCast Survey

- Hybrid and Fuel Cell Vehicles — 30% by 2019 (+/- 4 years)
- Non-Fossil Energy Resources — 30% by 2017 (+/- 6 years)
- Distributed Generation — 30% by 2021 (+/- 5 years)

The market shares of these and other "energy using" technologies, as well as the adoption of broadband and the many other "enabling" technologies, might suggest significantly different opportunities and impacts from the usual mix of reference case energy projections and future policy scenarios.

So We Might Ask: How Much of a Pollyanna?

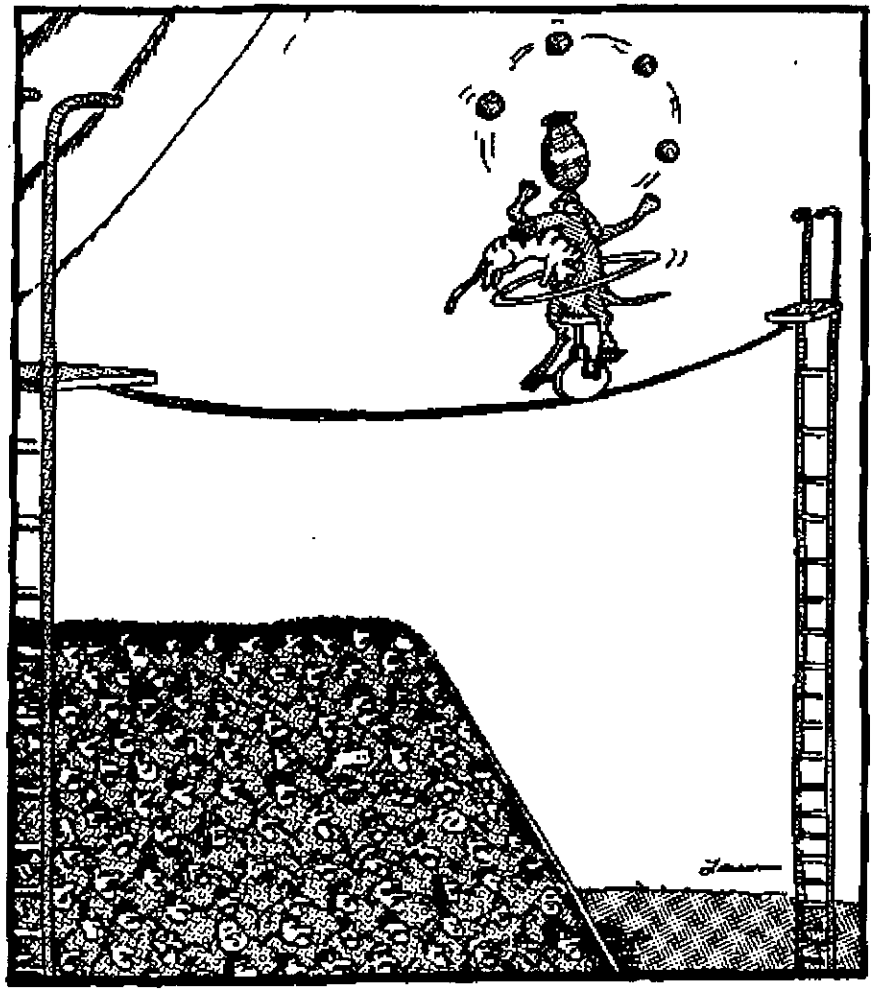
- Rather than a matter of thermodynamic, or even practical limits, it all depends on the social and policy choices which we make as a worldwide community.
- At the same time, these social and policy choices will clearly be impacted by both economic considerations and environmental concerns.
- But the demand for energy services, and the specific energy resources deployed to satisfy that demand — perhaps arbitrated by economics — still remains largely a matter of choice.
- ***So how much of a Pollyanna depends on just where and when we choose to invest in our future knowledge base and our development opportunities.***



"Well, somehow they knew we were—whoa! Our dorsal fins are sticking out! I wonder how many times *that's* screwed things up?"

A Thought Experiment: What if We Begin to Really Think in Terms of Integrated Systems?

- If technology is represented at all in economic policy models, it tends to reflect only discrete structures and isolated energy systems; for example, PV systems might be mounted on top of building roofs.
- But, what if we instead include, yes, building integrated PV systems (BIPV) — but ones based on light emitting polymers, together with other materials and alloys that are more completely integrated into a single structural composite? In such a case we can then imagine individual structural components that do the work of five separate systems, providing:
  - Structural support,
  - Thermal comfort,
  - Lighting needs,
  - Power generation; and
  - Information flow and processing.
- ***In this example: (a) efficiency improvements can be perhaps two or three times as large as energy models might otherwise suggest, and (b) conventional concepts like E/GDP and energy intensity may no longer have the same relevance as today's familiar set of metrics.***



High above the hushed crowd, Rex tried to remain focused. Still, he couldn't shake one nagging thought: He was an old dog and this was a new trick.

Final Reflections

- If we actively look for them, the "practical opportunities" for energy efficiency may be two or even three times the conventional wisdom.
- This is especially true as the analysis is more properly broadened to reflect new materials, technologies, and management practices as well as changes in demographics, social perceptions, and cultural norms.
- Moreover, the opportunities may be broadened even more when we think in terms of policies and price signals that can accelerate the pace of innovation and market penetration.
- ***But this all implies modeling capabilities that reflect and inspire these "images of the future."***

The difficulty lies not with the new ideas, but in escaping the old ones

John Maynard Keynes

And Perhaps This Final Perspective . . . .

Nolan Ryan is a hall of fame pitcher who closed his career in 1993 with the President's former team, the Texas Rangers. But he would have won considerably fewer than his 324 games had he taken the field without his catcher, his infield, or even outfield. ***In a similar way, the full mix of efficiency technologies should be among the modeling options as we map our future energy policy scenarios and evaluate the economic impacts of our alternative technology paths.***

For more information on the material or ideas referenced in this presentation, contact:

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The ideas contained in this presentation to the Emerging Technologies Summit are believed to rely on credible and accurate sources of information. Any errors in the analysis are solely the responsibility of the author. The results described herein should not be construed as reflecting the official views of either the Environmental Protection Agency or the U.S. Government. A more complete analysis that underpins this presentation can be found in Laitner, John A. "Skip," 2004. "How Far Energy Efficiency?" *Proceedings of the 2004 ACEEE Summer Study on Energy Efficiency in Buildings*, Asilomar, CA.