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Toward a Thoughtful Understanding of the Energy Efficiency Imperative

*New Insights, Attitudes and Motivated Behaviors**

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*** In the spirit and tradition of Nobel Laureate and former Caltech physicist Richard Feynman, in his 1959 visionary talk, "There's Plenty of Room at the Bottom." See, http://www.its.caltech.edu/~feynman/plenty.html.**

A Working Hypothesis

The economic recovery and the full development of our nation's long-term prosperity will not be possible without significant improvements in purposeful investment and greater levels of resource and energy efficiency – all motivated by informed attitudes, and more productive behaviors.

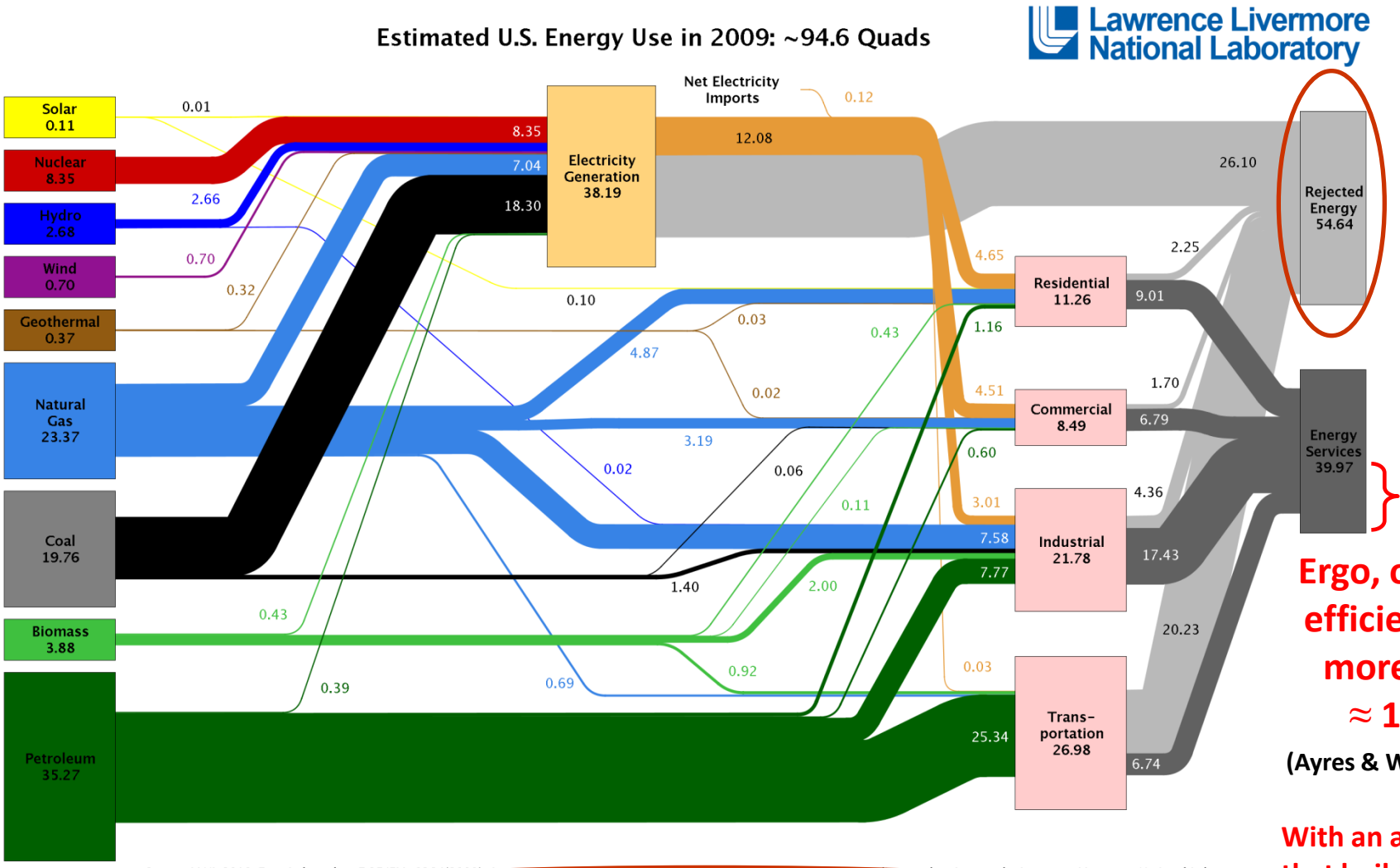
A Little Bit About Attitudes and Behavior

- Two important elements shape behavior. . . .
  - First, behavior follows awareness, attitudes, and motivation (and not the other way around)
  - And second, recalling Joan Robinson's admonition which remains true today, that: "Economics science has not solved its first problem - namely, what determines the price of a commodity?" (From her 1947 book, An Essay on Marxian Economics. London, England: MacMillan Press)

“We shape the world by the questions we ask”

Physicist John Wheeler

What is Wrong with this Picture?



Source: LLNL 2010. Data is based on DOE/EIA-0384(2009), August 2010. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports flows for non-thermal resources (i.e., hydro, wind and solar) in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 80% for the residential, commercial and industrial sectors, and as 25% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

Ergo, 42% efficient! But really?

useful energy

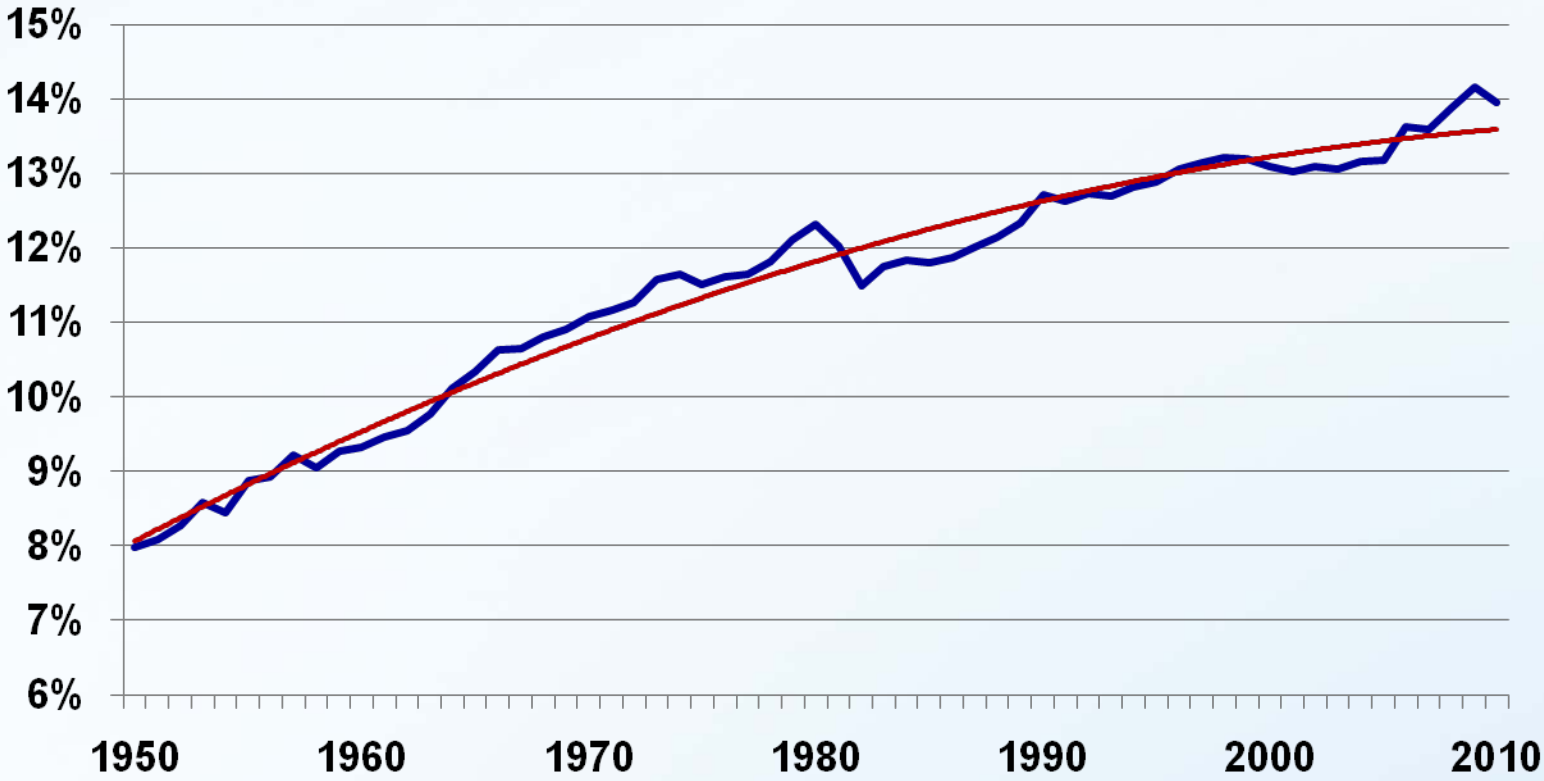
Ergo, overall efficiency is more like ≈ 13%

(Ayres & Warr, 2009)

With an assumption that buildings and industry are 80% efficient – and that ain't at all true. . .

And the very fine print ?

Conversion Efficiency
Primary Energy to Useful Work



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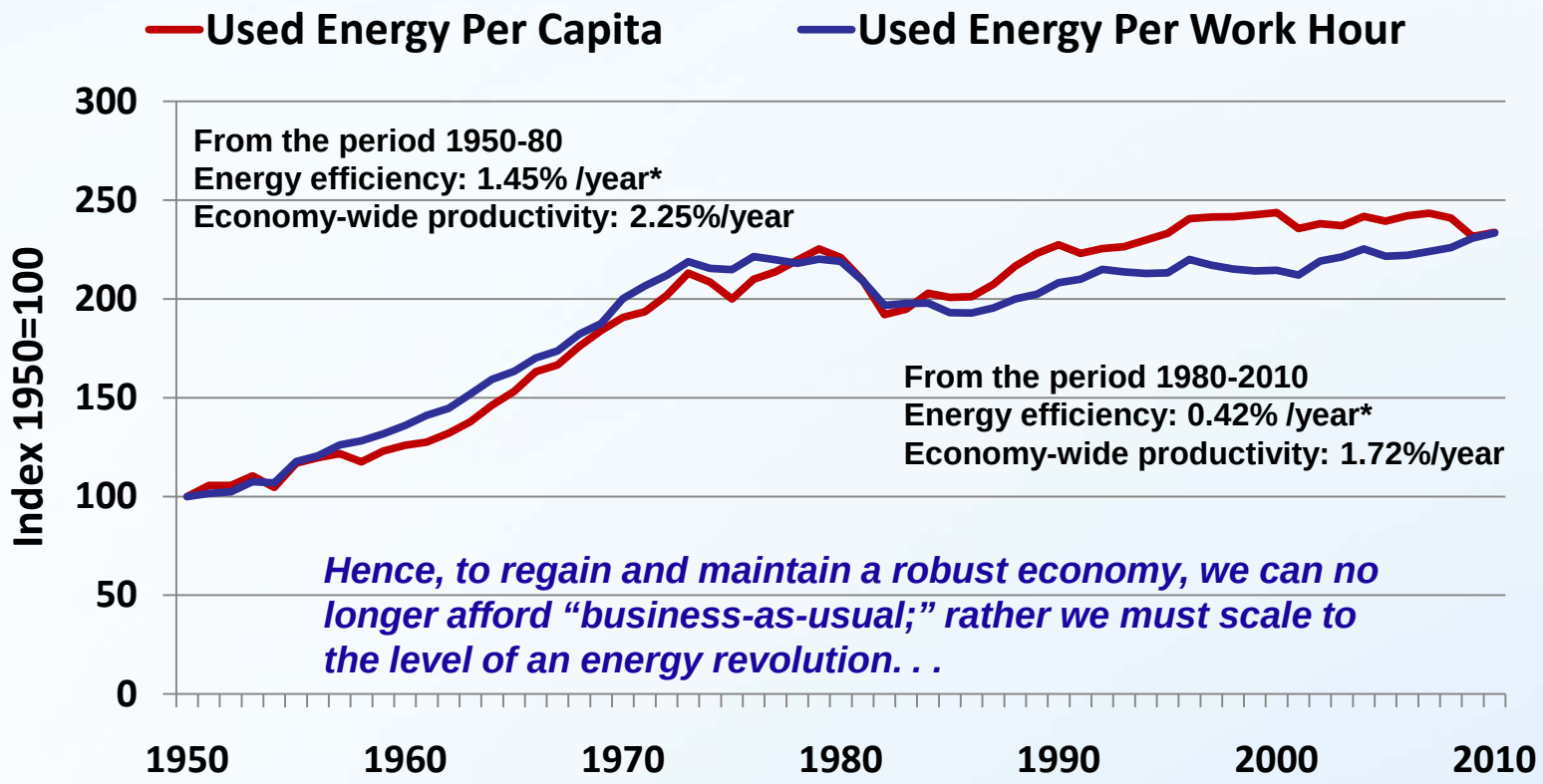
Source: *Ayres and Warr 2009 with data updates from 2005 to 2010 by Laitner*

Emerging Insights in the Critical Role of "Used Energy" to Enhance Productivity



* Here energy efficiency refers to the conversion of total primary energy to used energy
Source: Laitner 2011 (forthcoming).

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A Thought Experiment: the Economic Imperative of Energy Efficiency in Context

- The economic imperative of energy efficiency requires that we double or more our historical rate of energy efficiency improvement through a lowered cost of energy services.
- Following only the historical rate of efficiency gains may imply a ~0.3% to 0.5% smaller rate of per capita income or economy-wide productivity.
- If just a 0.3% decline in economy-wide productivity, the difference could mean a GDP (measured in 2005 dollars) that grows from $13.2 trillion in 2010 to ~$21.6 trillion rather than ~$22.7 trillion by 2030.
- An economy that is ~$1.1 trillion smaller by 2030 implies perhaps ~$350 billion fewer dollars in that year alone that is otherwise available for either investment or government revenues.
- Over the period 2011 through 2030 that might be $2.8 trillion in fewer available investment and government revenues.

And now exploring behavioral elements within a modeling construct. . . .

Jumping to the End of the Story: Diagnostic Runs with the DEEPER Model*

Scenario Comparison - Year 2030	Run #1	Run #2	Run #3	Run #4	Run #5	Run #6
Emissions	CO2 Only	All Gases	All Gases	All Gases	All Gases	All Gases
Target Reduction	45%	45%	45%	45%	45%	45%
Policy Levers	Price Only	Price Only	Price/Tech	Price/~2Tech	Price/~2Tech	Price/~2Tech
Hurdle Rate Start	30%	30%	30%	30%	30%	30%
Hurdle Rate End	30%	30%	30%	30%	25%	20%
Year 2030 Results						
Emissions Price ($/tCO2e)	$268	$188	$145	$107	$65	$25
Quad Savings	36%	29%	33%	36%	41%	47%
Price Increase	100%	70%	54%	40%	25%	11%
Expenditure Increase	27%	21%	4%	-11%	-26%	-41%
Ref Case Emissions	6,640	7,956	7,956	7,956	7,956	7,956
Pol Case Emissions	3,630	4,352	4,331	4,309	4,309	4,309
Emissions Reductions	45%	45%	46%	46%	46%	46%
PolCase Cum Invest (Bln $2007) *	1,681	1,223	1,479	1,766	2,115	2,633
Start Year Payback	2.95	2.95	3.08	3.14	3.14	3.14
Last Year Payback	6.08	3.17	6.64	6.94	7.44	8.61

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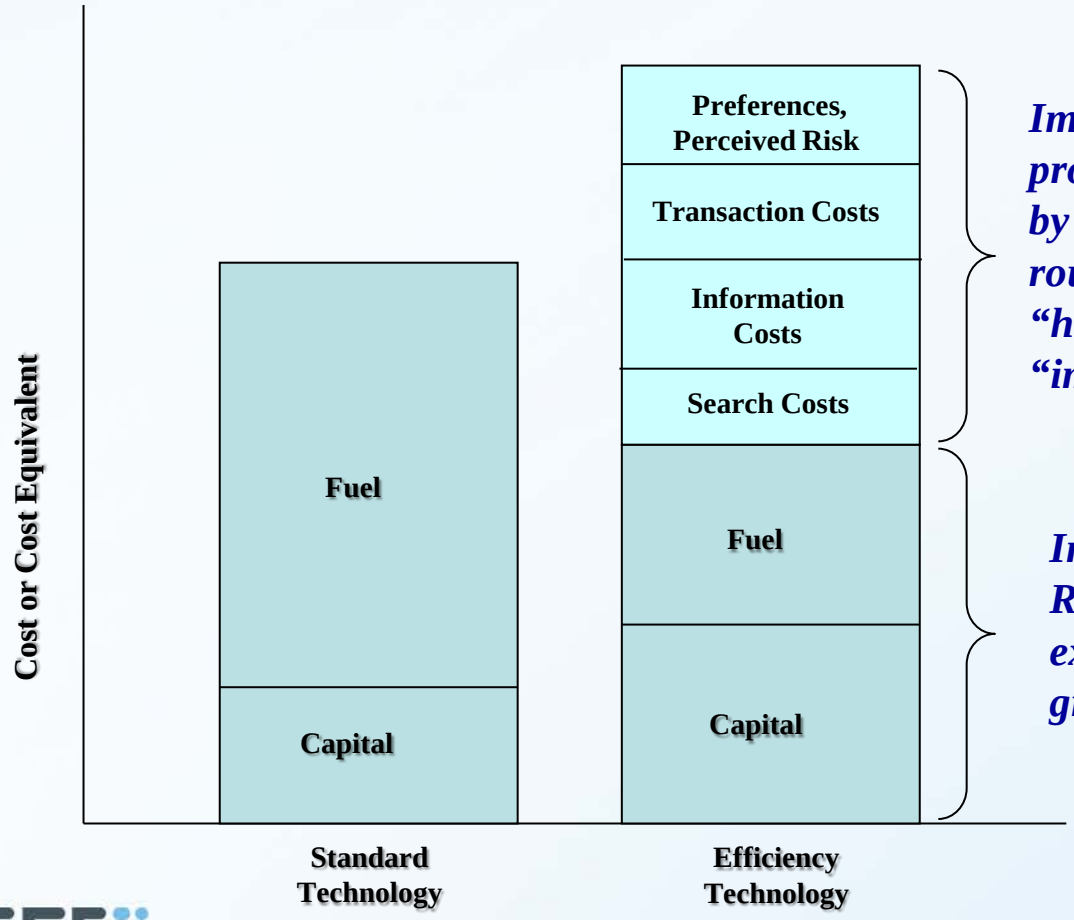
*DEEPER is the **D**ynamic **E**nergy **E**fficiency **P**olicy **E**valuation **R**outine

And how’d we get there?

Economics Science Has Not Solved. . . .

- The very first problem – namely, what determines the price of a commodity? (Robinson 1947)
- Among things that can influence commodity prices:
  - Beliefs
  - Values
  - Habits
  - Norms
  - Alternatives
  - Necessity
  - Income
- All of which can be shaped by changed perceptions, clear and persistent policy signals, as well as new or expanding programs (Geller et al. 2006, and Brown et al. 2009).

Comparing Hardware and Energy Costs with "Soft" Search and Transaction Costs



Impacted by policies, programs, awareness, and by shifting preferences – all roughly approximated by the "hurdle rate" or the "implicit discount rate"

Impacted by policies, R&D programs, experience, and growing expectations

Source: Laitner 2009

In DEEPER: the Investment Decision

Is determined by the condition:

$$\left.\frac{dK}{dE}\right|_{\bar{S}} = -P_E / r$$

A focus on the price-preference ratio

which is the point on the isoquant at which its slope and the factor price ratio are equal, i.e., the tangent point. A high value for the hurdle rate, *r*, implies that only energy-efficiency investments with a short payback will be undertaken.

But we also allow *r* to be impacted by program expenditures that we track, and under specific scenarios which we might explore, by changing consumer preferences as households and businesses become more aware of pending energy shortages and/or climate change.

At the same time, we can also incorporate equipment and appliance performance standards as well as flexible and/or tradable CAFE permits and similar policies.

Source: Laitner and Hanson 2006

Just where do we get these values?

Working Review of Program Effectiveness

Program Mechanism	Reduction in Energy Consumption	Study
Feedback	10-30%	Winker and Winett 1982
	36%	Hackett 1987
Feedback and Commitment	10 – 30%	Hutton et al. 1986 (and others)
Residential Feedback	4-12%	Ehrhardt-Martinez , Donnelly and Laitner (2010)
Energy Audits	+	
Information Programs	0-9%	Collins et al. 1985
Financial Incentives*	24-35%	Katzev and Johnson 1987
	4-28%	Collins et al. 1985
Convenience Disincentives	33%	Van Houten et al. 1981
Financial Disincentives	67%	Kohlenberg et al. 1976
Group Contingencies	5-15%	Katzev and Johnson 1987
Modeling	17%	Winett
Commitment and Feedback	15%	Becker 1978
Multiple Request Compliance	+	Katzev and Johnson 1983, 1984
Social Norms	+	Schultz et al. 2007
Social Marketing	19%	Cullbridge Marketing and Communications 2007
Other Combined Programs Energy Star	4% nationally	EPA 2006a

Source: Ehrhardt-Martinez 2009

And where else do we get such data?

By our collective, informed and learned judgment, but not necessarily through the availability of quality time series and/or case study data to help integrate the social and behavior aspects into our energy models. . . .

Hence the critical need for better and coordinated research and data assessment and collection. . . .

Underpinning This Overview: A Selected Bibliography on Behavior and Technology Characterization

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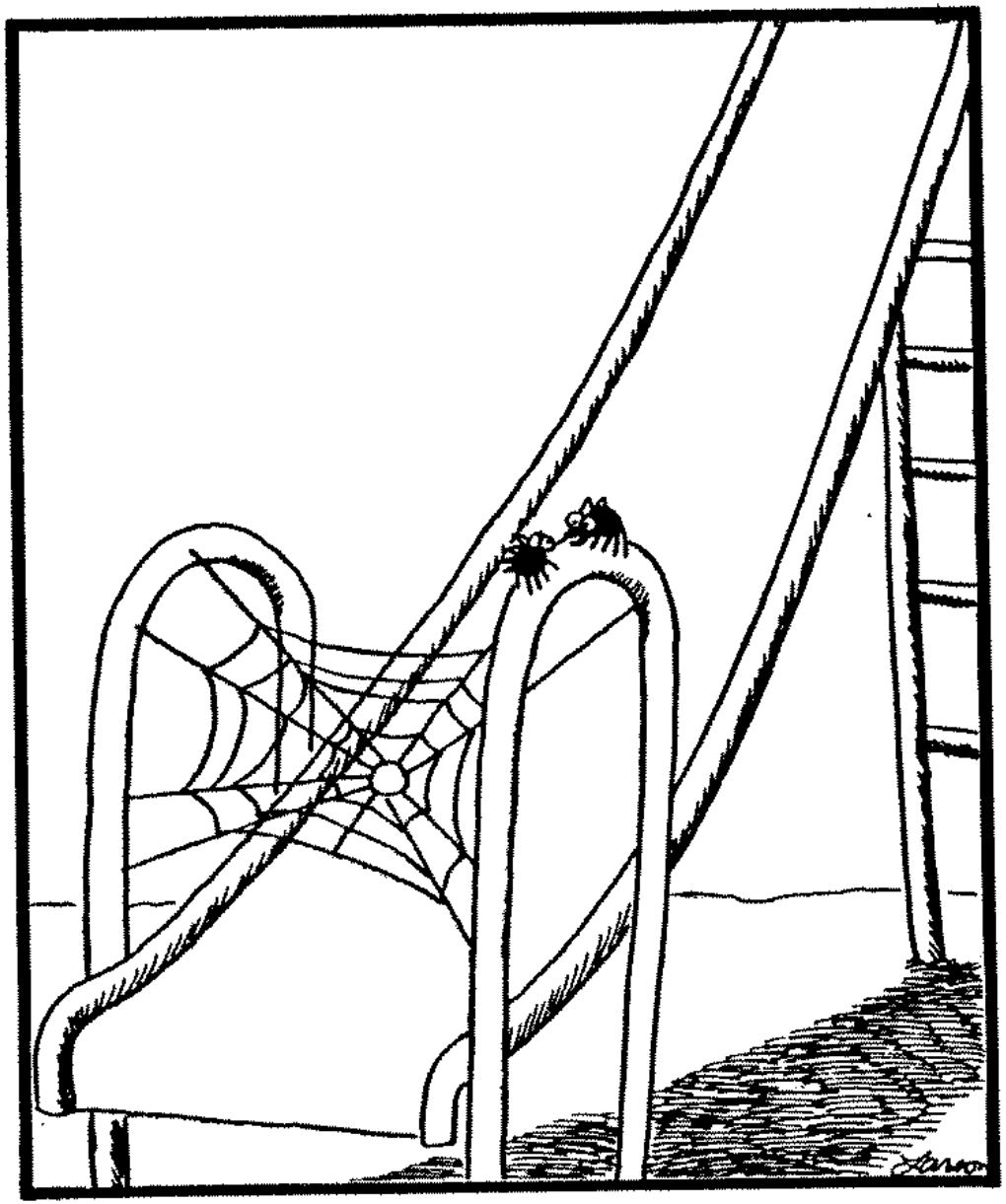
Note: Other citations can be provided on request.

Our Ultimate Energy Efficiency Resource?

- Recalling the comment of early Twentieth Century UK essayist, Lionel Strachey, who remarked: *“Americans guess because they are in too great a hurry to think.”*
- Jerry Hirschberg, founder and former CEO of Nissan Design, who noted that: *“Creativity is not an escape from disciplined thinking. It is an escape with disciplined thinking."*
- And Henry Ford once said, *“Thinking is the hardest work there is which is the probable reason why so few engage in it.”*

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

John Maynard Keynes



"If we pull this off, we'll eat like kings."

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